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ABSTRACT

Regional workshops sponsored by the National Institute for Educational Research (Japan) were held to strengthen national efforts in the development of elementary science aids/materials. This document provides: (1) guidelines for the development of appropriate and low-cost aids for science instruction; (2) inventory of aids; (3) synthesis of experiences relating to the development of the aids (focusing on teacher education/development, use and availability of aids, curriculum, school level organization, instructional strategies, and financial support); and (4) recommendations. The major emphasis of the document is on the low-cost aids, grouped under the following headings: Basic Tools, Living Things, Matter, Energy, and Earth and Sky. (The division of science into these content areas is common in the elementary science programs in Asian and Pacific countries.) A brief description is given for each item. In addition, content, skills, and attitude objectives are listed when appropriate, materials for construction are listed, instructions for making the device are outlined, and suggested uses and modifications are provided. Among the aids described are a spirit burner for supplying heat, micro-balance, single-pan/spring balances, laboratory stands, water clock, thermometer, box of biological tools, plant press, stethoscope, breathing system, potometer, electricity kits, weather apparatus, and electric motors. (Author/JN)

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LOW-COST AIDS FOR ELEMENTARY SCIENCE TEACHING IN ASIA AND THE PACIFIC

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LOW-COST AIDS FOR ELEMENTARY SCIENCE TEACHING IN ASIA AND THE PACIFIC

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PREFACE

In the school curriculum in the region, science is given special emphasis, and there exists the need to provide actual and practical learning experiences and to place less reliance on rote memory and dependence on textbooks alone. Many countries are still struggling with the problems associated with the introduction of new and basic science content and teaching methods, and also facing the problems of lack of funds to supply a variety of materials to schools.

Recognition of the need to relate pupils' learning to real-life situation as well as the above constraints has brought about the emphasis of using the environment and locally available materials for teaching-learning purposes which may contribute to some extent to overcome the shortage of financial and educational resources.

For the purposes of sharing various experiences and further strengthening national efforts in the development of science aids and materials, the National Institute for Educational Researh (NIER) of Japan has oragnized the following three regional workshops on the development of appropriate aids for sicnece teaching at the first level of education, in co-operation with the Asian Centre of Educational Innovation for Development (ACEID), Unesco, within the framework of the Asian Programme of Educational Innovaiton for Development (APEID).

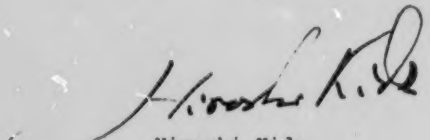
1) First Regional Workshop: 18 January - 17 February 1979
2) Second Regional Workshop: 22 November - 20 December 1979
3) Third Regional Workshop: 14 October - 8 November 1980

In all these workshops, special consideration was made to the development and use of appropriate and low-cost aids, the training of teachers in the production, use and maintenance of such aids, the relevance of aids to the science curriculum, and teaching methodologies or strategies. A number of write-ups on appropriate and low-cost science aids were developed through these workshops.

In order to synthesize the outcomes of the past three workshops, a Regional Workshop for the Compilation of an Inventory of Appropriate Aids for Science Teaching was organized from 11 November to 1 December 1981. In this last workshop, all the write-ups on appropriate and low-cost aids developed by the previous workshops were thoroughly reviewed and this publication was compiled as a single combined report of all the four workshops.

I sincerely hope that this publication will serve as one of the basic reference materials in developing appropriate and low-cost science aids in Asian and Pacific countries.

I would like to express my deep appreciation to all the participants of the four workshops for their outstanding contributions which led to the publication of this report as valuable outcomes of their concerted efforts. The Institute also wishes to record its special appreciation to Mr. Don Ferguson, Science Education Officer, Department of Education, New Zealand, for his support in finalizing this publication and for preparing typescripts.



Hiroshi Kida
Director General

CONTENTS

		Page
Preface		iii
Chapter I	Guidelines for the Development of Appropriate and Low-cost Aids for Science Teaching	1
Chapter II	Inventory of Appropriate and Low-cost Aids for Science Teaching	5
	- Basic Tools	7
	- Living Things	41
	- Matter	65
	- Energy	79
	- Earth and Sky	129
Chapter III	Synthesis of Experiences Ralating to the Development of Appropriate and Low-cost Aids for Science Teaching	141
Chapter IV	Recommendations	149
Annex	List of Participants	151

CHAPTER I

GUIDLINES FOR THE DEVELOPMENT OF APPROPRIATE AND LOW-COST AIDS FOR SCIENCE TEACHING

1. INTRODUCTION

These guidelines have been drawn up after careful consideration of the varied needs, problems, curricula and environments of the participating countries. The purpose of the guidelines is to serve as a yardstick for the selection of appropriate and low-cost science teaching aids at the elementary level.

Teaching aids at the elementary level (approximately the first 5-7 years of schooling) should emphasize the development of process skills, e.g.,

observing	predicting
classifying	hypothesizing
measuring	experimenting
inferring	control of variables

communication skills, e.g.,

- observational drawing
- recording data in tables, simple graphs
- interpreting data

and the development of scientific attitudes, e.g.,

curiosity	suspended judgement
originality	honesty
open mindedness	objectivity
care of environment	living things

In general such teaching aids should not be tied to any particular syllabus as these vary from country to country. However, the skills and attitudes of science are universal and teaching aids should develop these through experiences in the various science content areas.

2. DEFINITION OF TERMS

Teaching Aid: A device to be used by the teacher/pupil to facilitate the learning of the processes of science and to develop scientific concepts and attitudes. Such a device may be improvised from either indigenous materials or from simple, inexpensive, commercially produced items such as a dry cell.

Appropriate: Educationally sound;
Effective;
Suited to the learning abilities of children at the elementary level.

Low-cost: Can be prepared by the teacher/pupils from materials found in the local environment, or the materials can be bought without needing special financial assistance.

3. *GUIDELINES FOR DEVELOPMENT*

Guidelines for the selection of appropriate and low cost science teaching aids are listed below:

1) Materials for constructing the aids should be readily available.

2) The aid should be:

Relevant and appropriate (to the learners as well as to the concept/skill to be taught);

Economical in terms of time for construction, cost involved and effort required to make it;

Scientifically correct;

Simple in design, easy to make;

Clear in size, layout and proportion;

Attractive to users;

Safe and easy to handle;

Durable and easy to maintain and store.

4. *CONCLUSION*

In the process of the development of teaching aids, the following factors should not be overlooked.

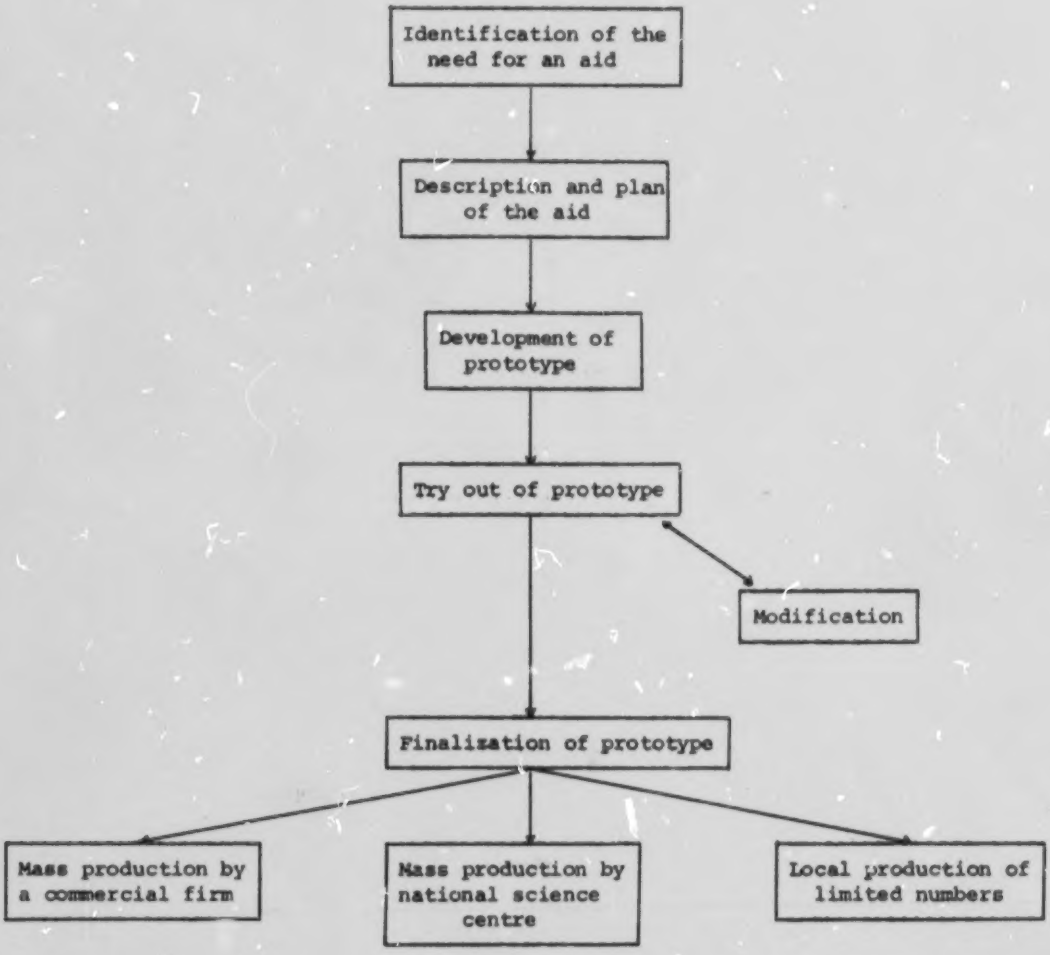
Identification of the needs;

Try-out of the aid;

Evaluation of its effectiveness;

Changes and modifications leading to its finalization.

The flow chart below summarizes the whole process:


Identification of the need for an aid
Description and plan of the aid
Development of prototype
Try out of prototype
Modification
Finalization of prototype
Mass production by a commercial firm
Mass production by national science centre
Local production of limited numbers

Aids found to be particularly effective should be submitted to a materials development agency such as a/an

local science centre;
national science centre;
equipment centre; or
commercial interests;

for their consideration for wider production and use.

The particular choice will depend on the country concerned.

Furthermore, teaching aids should not be developed for the sake of making teaching aids. Rather, they should be developed to serve an identified need.

CHAPTER II

INVENTORY OF APPROPRIATE AND LOW-COST AIDS FOR SCIENCE TEACHING

1. INTRODUCTION

The items listed in this section have been found to be useful in the teaching of science at the elementary school level.

Many could be constructed by the children themselves if sufficient materials are available.

They have been grouped under the following headings:

Basic Tools

Living Things

Matter

Energy

Earth and Sky

The division of science into these content areas is common in the elementary science programmes of many countries.

For each item, a brief description is given; content, skills and attitude objectives are listed where appropriate; materials for construction are listed; how to make the device is outlined; its uses are suggested and possible modifications are sometimes given.

There are many other devices which teachers and children could construct. This list is only a selection.

2. LIST OF INVENTORY ITEMS

Basic Tools

1. Spirit Burner
2. Simple Balance
3. Micro Balance
4. Single Pan Balance
5. Simple Spring Balance
6. Laboratory Stand 1
7. Laboratory Stand 2
8. Force Measurer
9. Water Clock
10. Simple Thermometer

Living Things

1. Box of Biological Tools
2. Plant Press
3. A Simple Stethoscope
4. Breathing System
5. Simple Potometer
6. Transpiration by Plants
7. Effects of Temperature on Flies

Matter

1. Expansion of Liquids and Gases by Heat
2. Melting of Solids When Heated
3. Kit for showing Change from Solid/Liquid/Gas and Properties of Solutions and Mixtures
4. Buoyancy

Energy

1. Electricity Kit 1
2. Electricity Kit 2
3. Apparatus to Indicate the Flow of Electric Current
4. Neon Bulb Detector
5. Simple Electric Motor 1
6. Electric Motor 2
7. Galvanometer
8. Buzzer
9. Basic Light Kit
10. Model of a Camera
11. A Simple Telephone Set
12. Friction
13. Cotton-Reel Tractor
14. Walking Gyroscope
15. Air Circulation
16. A Water Generator

Earth and Sky

1. Cup Anemometer
2. Anemometer
3. Wind Vane
4. Barometer
5. Hygrometer
6. Star Box

SPIRIT BURNER

Description:

A simple apparatus for supplying heat.

Materials:

Bicycle valve base.

Bottle, short, with a wide mouth and a metal or bakelite cap (an ink bottle would be suitable).

Methylated spirits, or alcohol.

Tin, or jar, with a smaller diameter than the bottle.

Wick (cord).

Construction:

Using a drill or large nail make a hole the diameter of the bicycle valve in the centre of the bottle cap. Make another very small hole between the large hole and the edge of the cap.

Remove the nut from the bicycle valve and insert the valve base in the hole in the cap. It should be a tight fit. Screw the nut on tightly so that the valve is held firmly to the cap.

Place the wick through the valve base so that there is a coil of wick in the bottom of the bottle.

Fill the burner almost full with methylated spirits or alcohol. Screw on the top.

The burner is now ready for use.

After using the burner the flame should be put out, and to prevent evaporation of the methylated spirits a small can placed over the top of the burner.

Uses:

As a heat source.

Modifications:

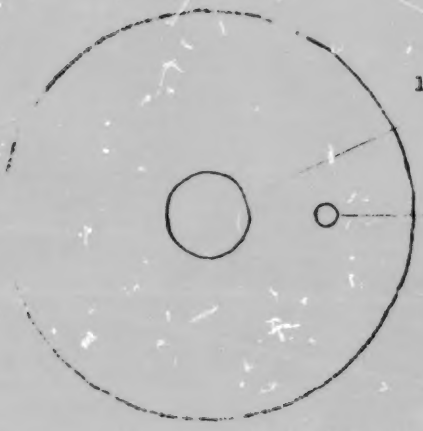
If a bakelite cap is used the holes would need to be drilled or made with a heated metal rod or nail.

Other caps could be devised, eg, a smaller bottle, a tin cap made by shaping and soldering a piece of tin.

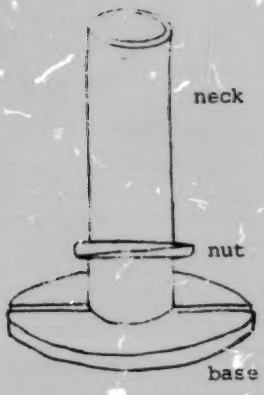
Precautions:

If a short bottle cannot be found then a weight should be placed in the bottom of the lamp to prevent it tipping over.

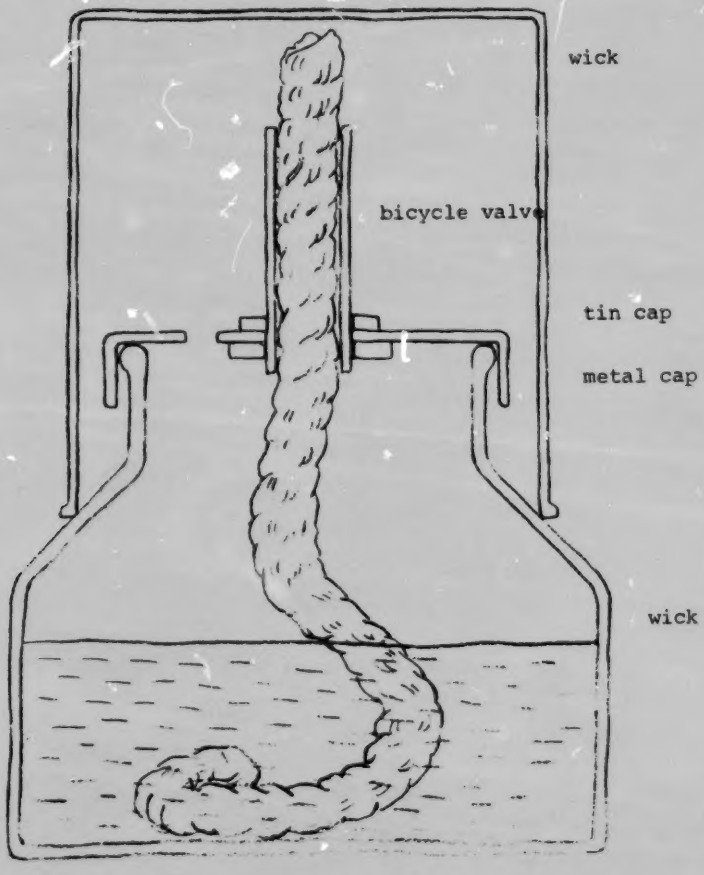
Burners should be used in metal or sand trays in case they are accidentally knocked over.



Matel Cap - Topview



Bicycle Valve



Bottle

SIMPLE BALANCE

Description:

This balance is a simple device to measure the mass of an object which weighs less than one gram and for comparing the mass of different objects.

Objectives:

The children can:

- explain that all objects including very tiny objects have masses;
- explain that different objects have different masses;
- use the process skills of measuring, comparing, recording, and interpreting data.

Materials:

Two wooden blocks:

(a) Base piece -- about 30 cm long, 5 cm wide and 2-4 cm thick.

(b) Stand piece -- about 25 cm long, 3 cm wide and 2 cm thick.

A thin "springy" metal strip about 40 cm long and 3 cm wide.

Two nails about 5 cm long.

Four nails about 3 cm long.

Hammer

Thread

Any small and light container for making a pan, eg, the inside part of a match box.

Standard weights.

A piece of white paper.

Glue.

Construction:

1. Fix one end of the stand piece to the base piece with the help of two nails as shown in Fig 1.

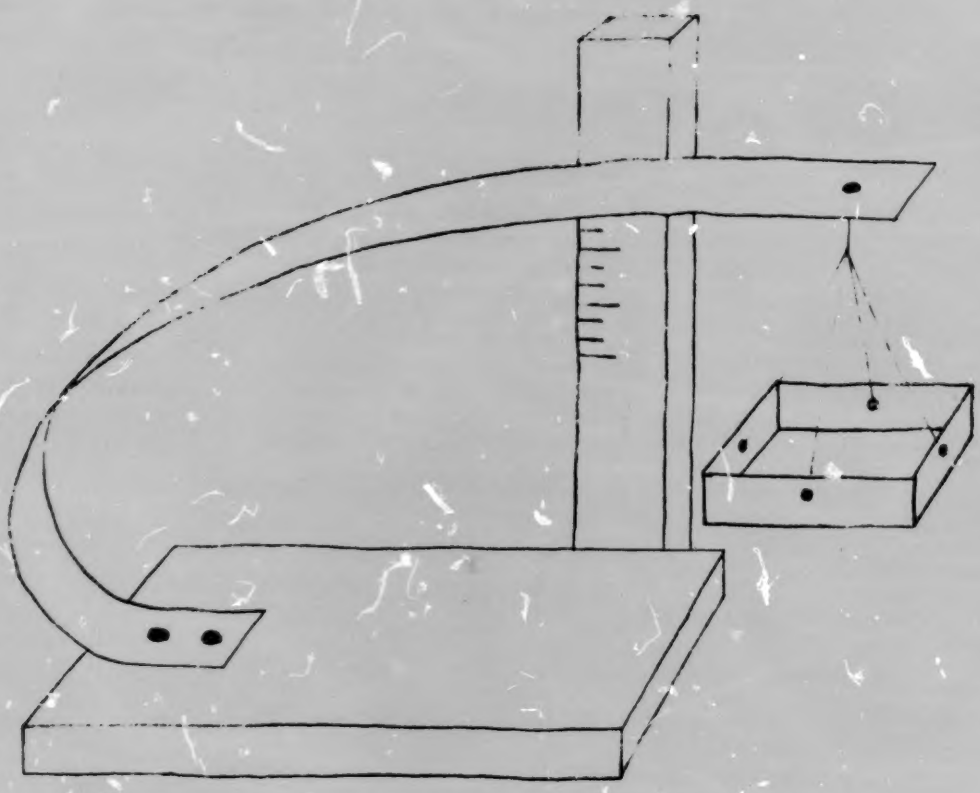


Figure 1

2. Glue a piece of white paper along the length of the stand.

3. Bend one end of the metal strip, about 5 cm from the end and make two holes at this bent end and one hole at the other end. Use a nail or drill. Fix the bent end on the base with two small nails (see Figure 1).

4. Make a scale as shown and fix this to the base.

5. Use the inside of a match box as a pan. Tie the pan with thread and fix it to the free end of the metal strip. To calibrate the balance mark a line on the paper where the end of the metal strip points when it is at rest. This is the zero position of the balance. Put a weight of 10 mg on the pan and watch until the strip comes to rest. Mark a line as before and this line represents the weight of 10 mg. Continue adding weights of 10 mg and marking lines on the paper to complete the calibration.

Use:

Collect small things such as pieces of ordinary paper, aluminium foil, etc. Weigh these small objects and note the weight and name of the materials respectively. After weighing all the different materials students could compare the masses of those materials. In this way students will learn the skill of measurement as well as being able to make comparisons of mass.

MICRO-BALANCE

Description:

It is very difficult to weigh very light objects using a sensitive commercial balance and these sensitive balances are also very expensive. This device, a simple and inexpensive drinking straw balance, allows students to appreciate that even the lightest objects, such as a human hair, have weight.

Objectives:

The children can:

- explain how the micro-balance can be used to find the mass of objects;
- construct a simple micro-balance;
- make measurements of the masses of various small objects;
- collect and record data;
- interpret data.

Materials:

Drinking straw

Used razor blade

Two small pieces of wood (8 cm x 3 cm x 1 cm)

A larger piece of wood (30 cm x 15 cm x 1 cm)

Wooden block (3 cm x 3 cm x 3 cm)

Nails

Ruler, or similar piece of wood

Paper

Wood glue

Small paper weights (use the waste from a hole puncher)

Screw or bolt (to fit into the end of a straw)

Construction:

Glue and nail the two small pieces of wood to the larger piece as shown in Figure 1. The separation between the two vertical pieces should be about 2 cm. Break the razor blade in half as shown in Figure 3 and fix the two halves of the blade to the top of the two vertical pieces by pushing the cutting edge into the wood (Figure 1). Ensure that the corresponding parts of the blade halves align with each other.

Screw the bolt (or screw) into one end of the straw and at the other end cut a 0.5 cm wide flat groove at a point about 3 cm from the end, and also shape this end into a pointer as shown. Glue a small piece of paper into the cut groove to form a balance platform.

At a point along the straw, about 5 cm from the bolt, push the needle through the straw being sure that it is horizontal and that it passes through the straw just above its centre (see Figure 2). Now place the needle on the razor blade supports and adjust the bolt or screw to make the straw horizontal.

Glue a paper scale to the ruler and then attach this to the wooden block. Glue this part to the base so the scale is in line with the pointed end of the straw (see diagram). Be sure that the scale is vertical.

Again adjust the bolt or screw to level the straw, if this is necessary, then mark the position of the pointer on the scale. This position is the "zero point".

Now calibrate the scale by adding regular masses (in this case the circular paper wastes) to the platform one by one, and in each case mark the position of the pointer on the scale.

Use:

Take a simple human hair and carefully put it on the platform. The pointer will move down to a certain point. Note the reading. This will correspond to the mass of hair. Then 'weigh' other types of human hairs (say black, brunette, blonde, brown, etc) or the hair of animals. Similarly pupils may find the mass of an object lighter than hairs such as a small piece of paper, etc.

Modifications:

Since this is a very sensitive balance it should be used in a place where it is protected from wind drafts. Therefore it is recommended that the balance should be enclosed in a cardboard box in which a small window has been cut.

An alternative, but less robust, construction is shown in Figure 4.

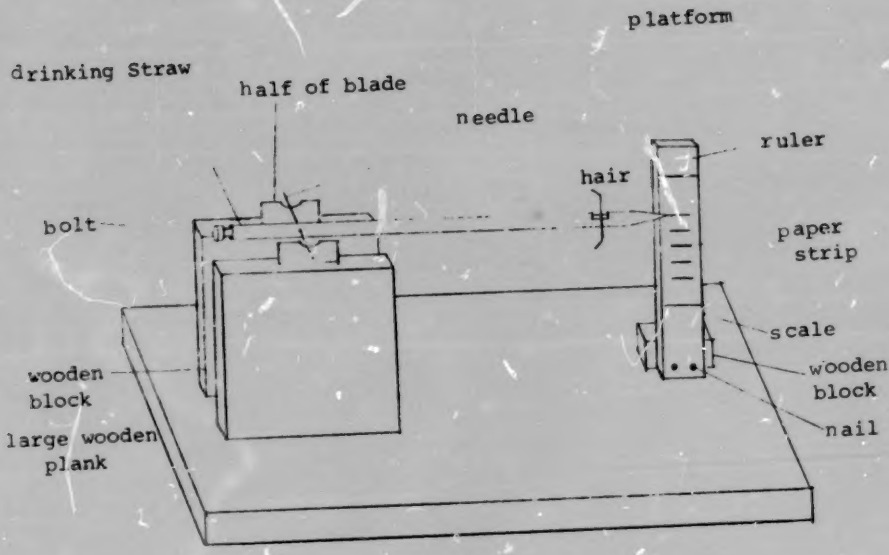


Figure 1

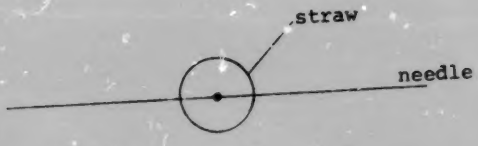
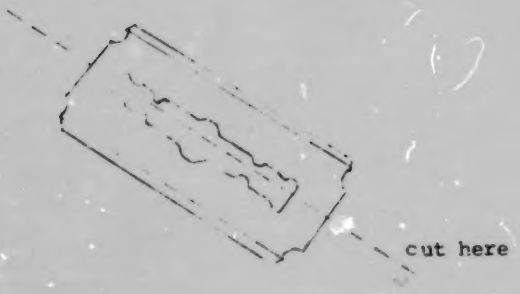


Figure 2

Figure 3



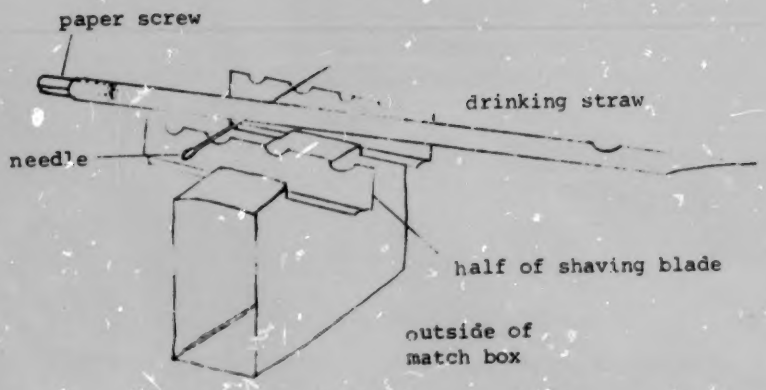


Figure 4

A SINGLE PAN BALANCE

Description:

This is a simple piece of equipment which can be used to determine the mass of various objects.

Objectives:

The children can:

- explain the extent of elongation of an elastic band or a spring depends on the force exerted on it;
- explain that substances have mass;
- show that different volumes of the same substance have different masses;
- show that the same volume of different substances have different masses.

Process skills which could be developed are measuring, classifying, and experimenting.

Age group: 9 - 11 years.

Materials:

Tin lid (about 8 - 10 cm in diameter)

Plastic container with a narrow mouth about 2 cm in diameter, height about 15 cm, base about 8 - 10 cm in diameter. (A conical shaped vessel is easy to keep stable.)

Discarded cotton reel

Piece of wooden dowell (round stick) or a pencil whose diameter should be slightly less than the diameter of the hole in the cotton reel

Rubber band, or a small spring

Piece of copper wire, about 15 cm long

Rubber adhesive paste

Construction:

Cut the cotton reel as shown in Figure 1.

Cut a vertical slit about 2 - 3 cm wide, leaving about 2 cm from the neck and bottom of the plastic container as shown in Figure 2.

Cut a piece of wire about 6 cm long and fix it to the end of the piece of round stick or pencil and fix a small nail in the round stick as shown in Figure 3.

Fix a hook, made of the wire, to the cut end of the reel as shown in Figure 4. This must be fixed in such a way that it allows free movement of the round stick.

Fix the tin lid to the other half of the cotton reel as shown in Figure 5.

Pass the free end of the round stick through the bottom reel with the hook, and attach the rubber band as shown in Figure 6. If a spring is used, it could be fixed similarly to the round stick as shown in Figure 7. If this is done, care must be taken to attach the two ends of the coil in such a way that the round stick can slide freely within the coil.

Insert the round stick through the mouth of the plastic container by tilting the bar sideways. This is easy if the top end of the vertical slit is very close to the neck of container as shown in Figure 8 and Figure 9. Push the bottom reel into the neck of the plastic container and fix the top reel with the pan to the free end of the round stick. The balance is now ready to be used as shown in Figure 10.

Calibrate the balance using standard weights.

Use:

Press downwards on the pan gently with the fingers. Now increase the pressure and watch what happens to the pointer.

Place various known weights on the pan and note the position of the pointer.

Weigh various objects, eg, iron nails of different sizes, pieces of wood of the same diameter but of different lengths.

Weigh various objects of the same volume but different weight.

Measure volumes of various objects using the displacement method.

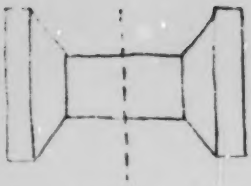


Figure 1

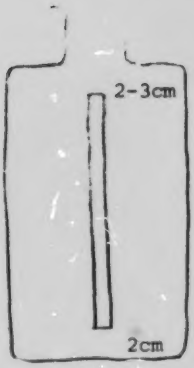


Figure 2

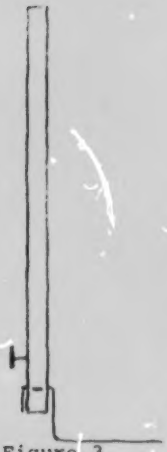


Figure 3

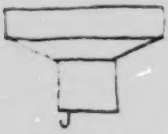


Figure 4

Figure 5

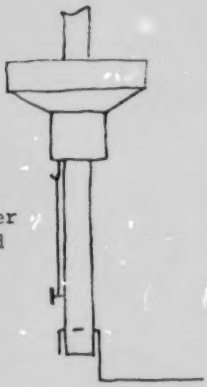


Figure 6

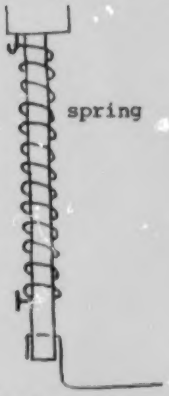


Figure 7

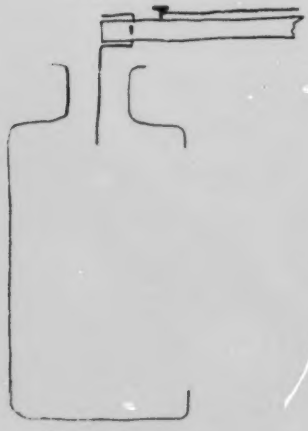


Figure 8

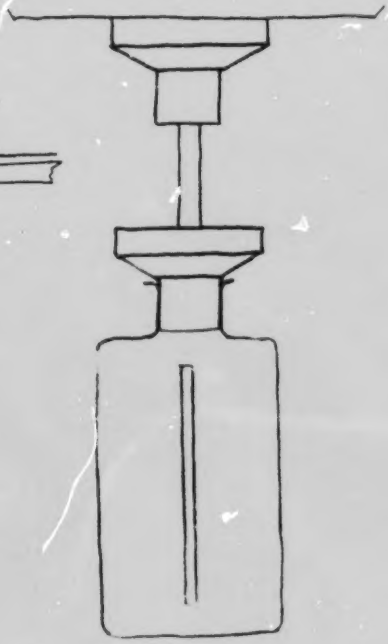


Figure 9

Figure 10

SIMPLE SPRING BALANCE

Description:

This simple spring balance is easily constructed and useful for weighing small objects.

Objectives:

As a result of making and using this device children should be able to show that:

- the extension of an elastic string depends on the force exerted on it;
- substances have weight and this weight can produce elongation in an elastic string;
- different volumes of the same substance have different weights;
- the same volumes of different substances have different weights;
- when a substance is immersed in a liquid a loss of weight occurs;
- a known force can be exerted on a body using this balance.

Materials:

Ball point pen (used)

Elastic string (15 cm)

Paper clips

Pin

Paper

Weights, small

Construction:

Separate all the parts of the ball point pen. The portion marked A in Figure 1 is cut and removed. The metallic part (ie, the ball point) of the inner tubing of the pen is cut and removed (B in Figure 1). A small pin is tied to the end of the elastic string (Figure 2), and threaded through the hole in the plastic tubing. A paper clip is fixed on to this plastic tubing at the lower end so that objects can be hung from it (Figure 3). Another clip is fixed to the upper cap of the pen (Figure 4) as shown. The plastic tubing (with the elastic string inside) is pushed through the body of the pen (Figure 5). The top cap of the pen (Figure 5) is screwed on to the body of the pen so that the upper end of the elastic string is clamped between the cap and the body of the pen.

Uses:

Calibration of the Balance: A known weight is hung from the lower clip (Figure 6) and the position of the upper end of the inner plastic tubing is marked (y). The position of the upper end of the inner plastic tubing when no weight is attached on the lower clip is marked (x).

A thin strip of paper of length slightly more than x - y is divided into 10 equal parts and these divisions are marked on this strip of paper (Figure 7). Paste this strip of paper on the body of the ball point pen with the marking on the paper facing down so that the markings are visible through the ball point pen.

1. By pulling the lower clip a force can be exerted and the elastic extended.

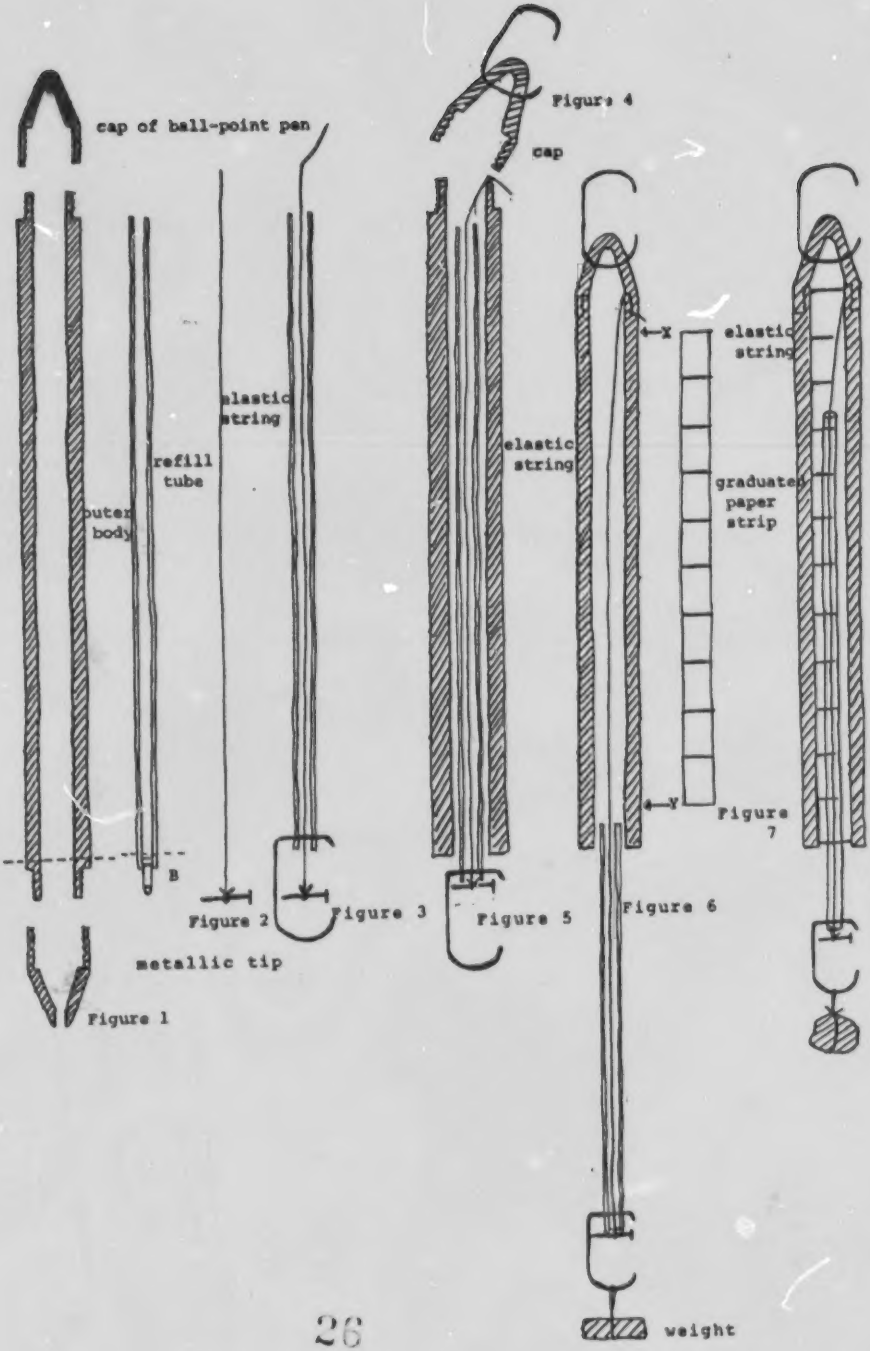
2. Different objects can be hung from the clip and the elongation measured. (using a ruler)

3. Different known weights can be hung from the clip and the elongation measured.

4. Different volumes of the same substance can be hung from the clip and the elongation observed.

5. The same volume of different materials can be hung from the clip and the elongation measured.

6. An object can be hung from the clip and the elongation observed. This object can be immersed in water and the apparent loss in weight observed.


cap of ball-point pen
outer body
refill tube
elastic string
B
metallic tip
Figure 1
Figure 2
Figure 3
Figure 4
cap
elastic string
Figure 5
X
Y
elastic string
graduated paper strip
Figure 7
Figure 6
weight

LABORATORY STAND 1

Description:

This is a simple laboratory stand made of wood and metal rods or thick wire.

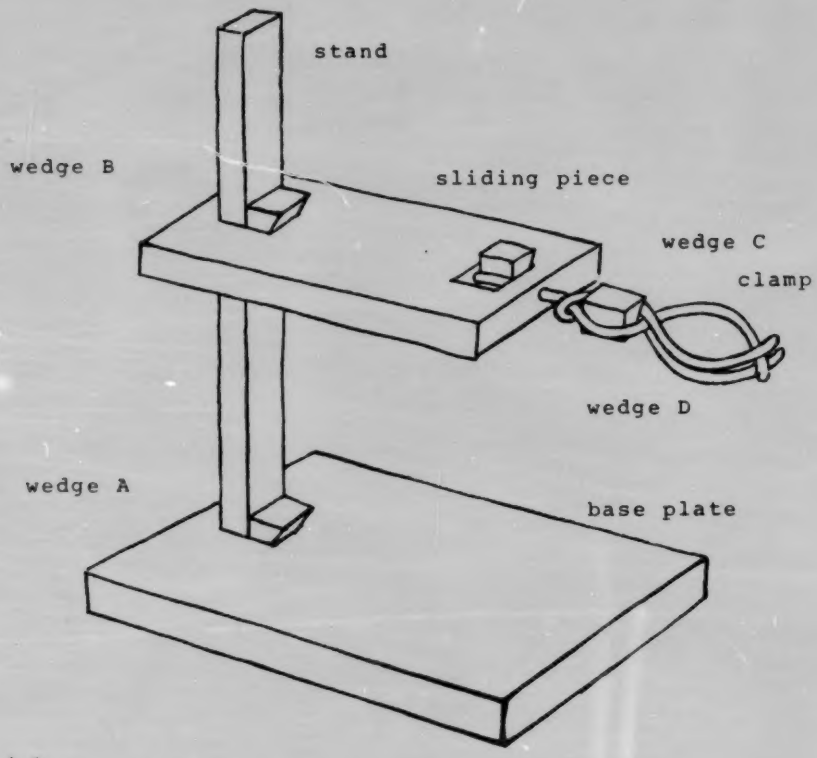


Figure 1

Materials:

Aluminium or galvanised iron rod, or thick wire, rubber tube, wood and basic tools for construction such as:

Chisel

Drills

Hammer

Plane

Pliers

Saw

Construction:

(A) Base plate

1. Prepare a wooden plank to size 30 cm x 20 cm x 2.5 cm.

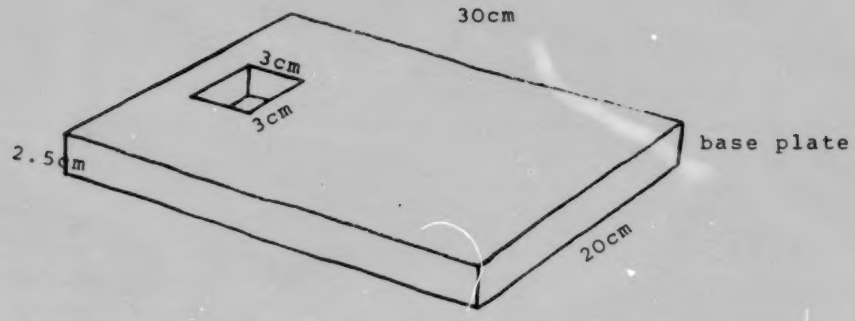


Figure 2

2. Make a square hole in the base as shown in Figure 2.

(B) Stand

Cut a wooden stick 100 cm x 3.0 cm x 2.4 cm.

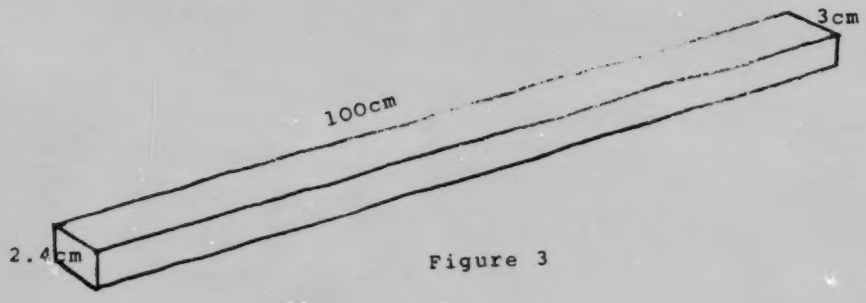


Figure 3

(C) Sliding piece.

Cut a piece of wood to the following size, 10 cm x 7 cm x 2 cm.

Make two square holes in the piece of wood, one 3 cm x 3 cm and the other 2.5 cm x 2 cm (Figure 4).

Bore a hole, 6 mm in diameter, for a distance of 5 cm through the centre of the sliding piece of wood (see Figure 5).

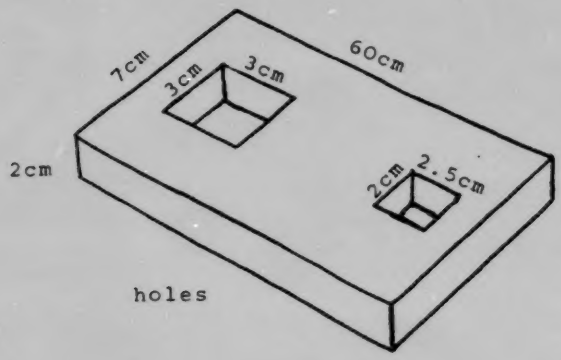


Figure 4

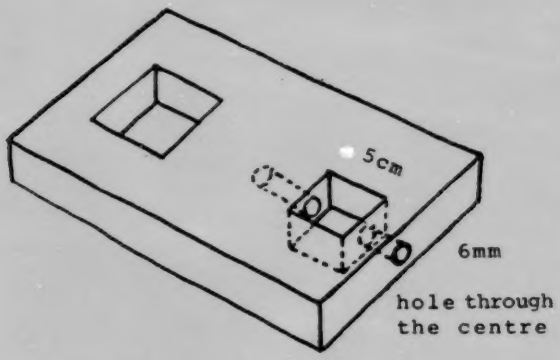


Figure 5

(D) Clamp

Take two aluminium/galvanised iron rods or pieces of wire 3 mm in diameter and about 20 cm - 25 cm in length.

Bend each rod as shown in Figure 6.

Insert each into a piece of tightly fitting rubber tube.

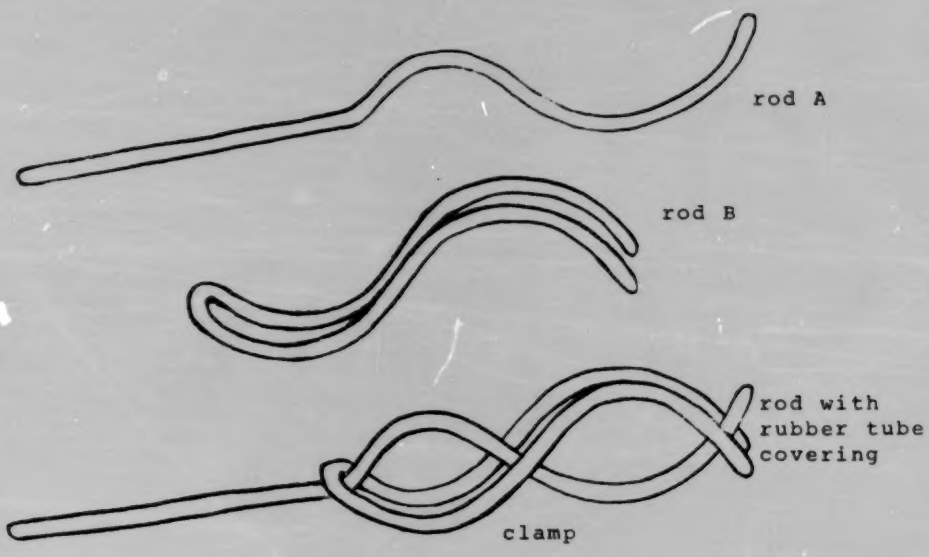


Figure 6

(E) Wedges

Cut 4 pieces of wood as shown in Figure 7.

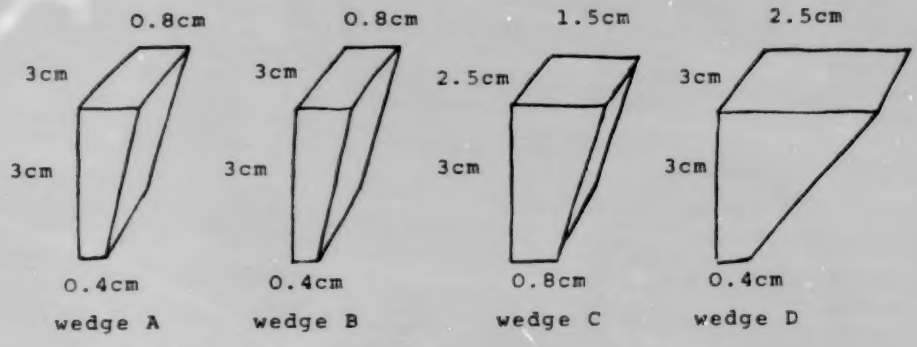


Figure 7

Use:

The clamp can be rotated to any position by slackening the wedge C. The stand and clamp will hold test tubes, flasks, etc of various sizes.

When the smallest opening of the clamp is desired the wedge is adjusted to its maximum diameter.

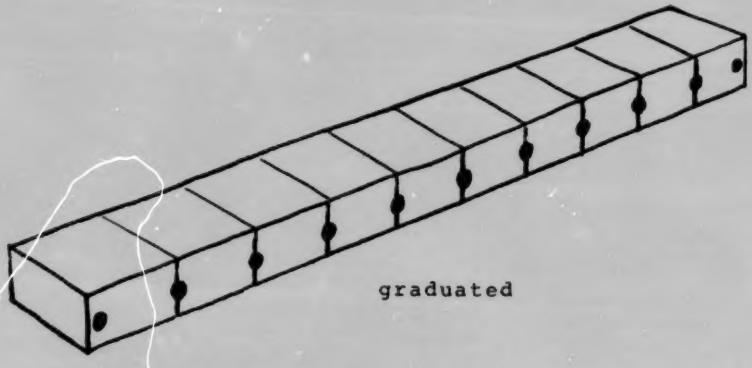
The sliding piece can be adjusted anywhere along the length of the stand and secured in position with wedge B.

When using this stand ensure that all the wedges are tight enough to support the object held in the clamp.

Modifications:

1. The stand can also be used separately as a metre scale if the upright is marked in centimeters.

2. If a hole is made in the upright and a lever arm is made, the stand can serve as a simple balance. Use a nail as the fulcrum (Figure 9). The lever arm could have holes drilled or screw eyes mounted so that objects can be hung from the arm.



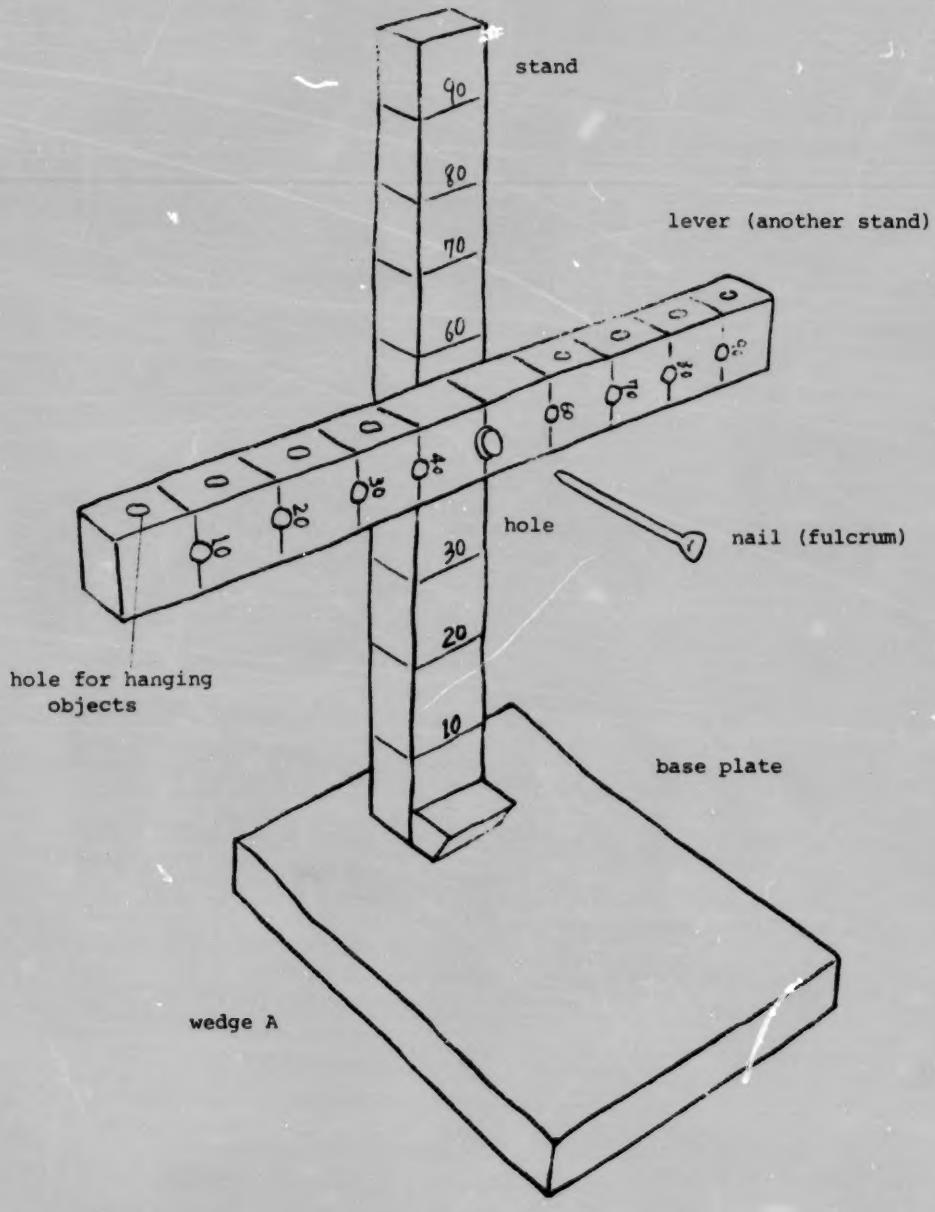

stand
lever (another stand)
hole
nail (fulcrum)
hole for hanging objects
base plate
wedge A

Figure 9

LABORATORY STAND 2

Description:

This simple laboratory stand can be made from bamboo.

Materials:

Bamboo stem - 40 cm long and 3 cm diameter

Can or pot

Clothes pegs (2)

Wood piece 16.0 cm x 6.0 cm x 0.3 cm

Wood screws (3)

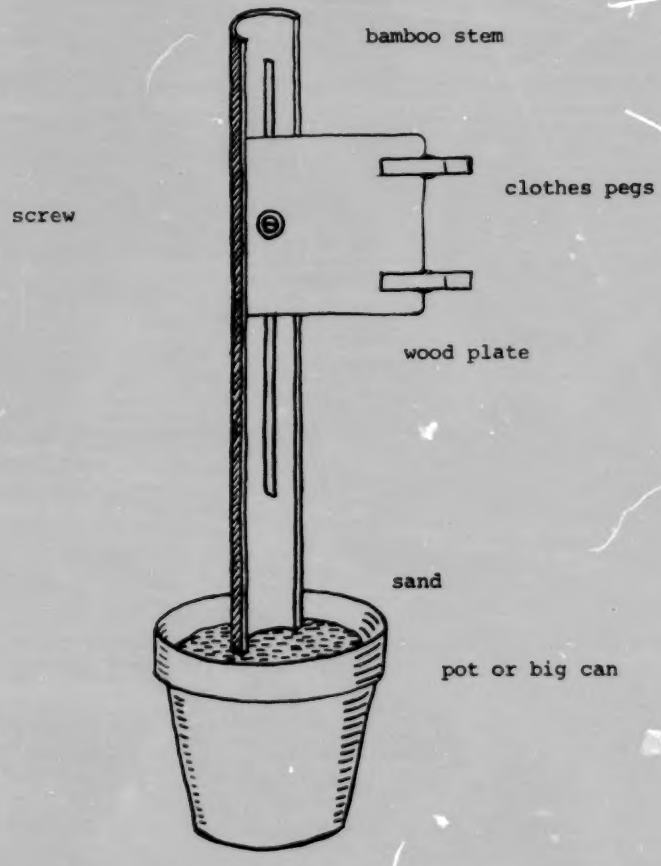


Figure 1

Construction:

Cut the bamboo stem longitudinally.

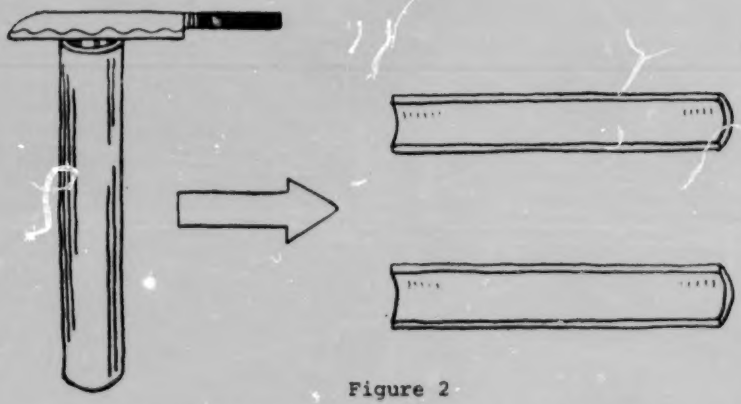


Figure 2

Make a groove in the middle of the piece of bamboo about 20.0 cm long and 0.5 cm width (Figure 3).

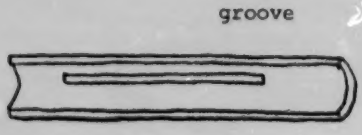


Figure 3

Make 3 holes of 0.5 cm diameter in the piece of wood (Figure 4).

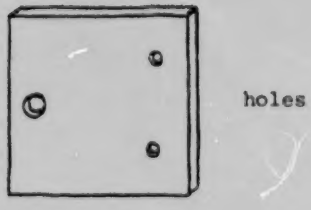


Figure 4

Make a hole of 0.5 cm diameter on each of the clothes pegs (Figure 5). Then fix the two clothes pegs to the wood plate by using the screws.

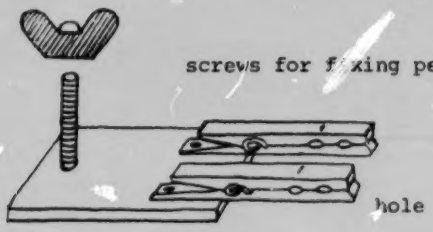


Figure 5

Fix the wood plate to the bamboo using a screw.

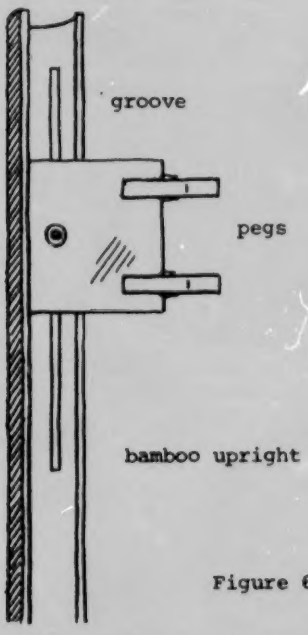


Figure 6

Place the bamboo stem to one side of the pot (or can) and fill the pot (or can) with sand or concrete.

Use:

This stand can be used for holding test-tubes, thermometers, and other objects which are not too big or heavy.

Modification:

A wooden base could be used. The bamboo upright would have to be glued to the base.

FORCE MEASURER

Description:

This is a simple but very effective device for measuring forces.

Objectives:

As a result of making and using this device children should be able to:

- discuss the use of units of measurement;
- prepare and calibrate a measuring scale;
- measure forces in a variety of situations, eg, frictional forces, magnetic forces, weight;
- apply known forces in an experimental situation.

Age level: 10+ years.

Materials:

Wooden blocks of approximate size:

(i)	25 mm cube	(Block A in Figure 1)
(ii)	100 x 50 x 10 mm	(Block B in Figure 1)
(iii)	320 x 130 x 10 mm	(Block C in Figure 1)

Thread and simple wire hooks, eg, paper clips

Bolt: approximately 30 mm long, 5 mm diameter

Nut to fit the bolt (a wing nut is best)

Hacksaw blades (or similar spring metal strips)

Card or paper strips for scale (approximately 150 x 50 mm)

Nail, 5 mm diameter

Nails, glue, etc, for fixing the pieces of wood together

Metal sheet of thin guage, approximately 60 x 100 mm

Spring Balance

Construction:

The completed force-measurer is shown in Figure 1.

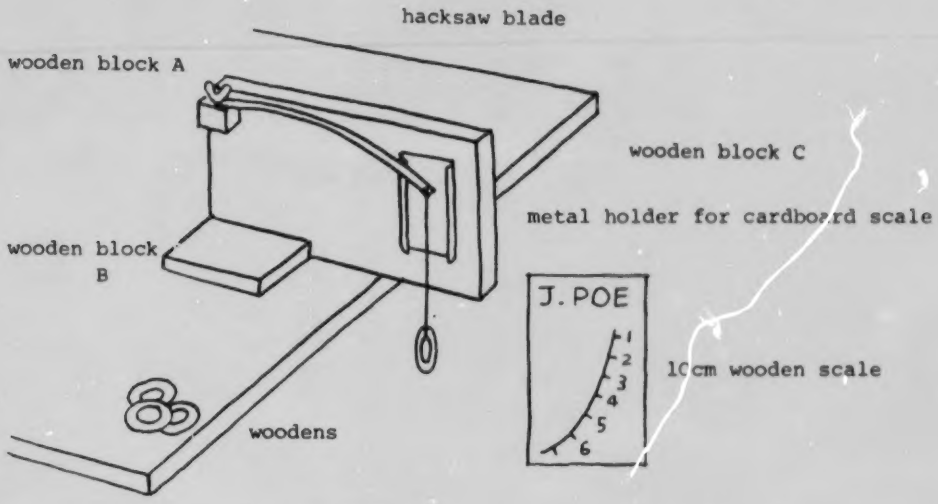


Figure 1

In assembling the force-measurer you will need to:

(i) strongly glue or nail block A to block C;

(ii) use a blade with holes in each end or drill them;

(iii) fold the piece of metal to form a holder for the paper or cardboard scale. It is essential that the scale can be moved up or down as required.

Note: For large forces you will need to use more than one blade. If possible these should be spot welded together.

Use :

A. Calibration in any unit of force

With a blank scale card in position mark the "zero" position of the blade.

Deflect the blade by hand a few times. Does it always return to the ZERO position? If not, check that the blade is tightly mounted, and that the card is not slipping. Now use a number of IDENTICAL washers, or IDENTICAL nuts, or IDENTICAL fishing weights, etc, to graduate the card. This scale can then be used to weigh other objects in terms of 'so many washers' or 'so many nuts'. (See Figure 1.)

B. Calibration against a standard

Place the FORCE MEASURER so that its blade moves horizontally, with a blank card in position. Use a commercially made spring balance to pull the blade aside horizontally, so that the weight of the commercial force measurer does not hang on the blade, and so affect the calibration.

MARK the card in the units of the spring balance (Figure 2).

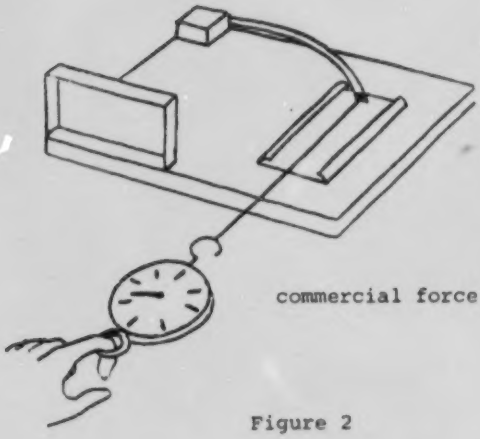


Figure 2

C. Measuring and applying forces

1. Measuring Limiting Friction

Use the FORCE MEASURER to apply horizontal forces to a block to cause it to just start sliding over a flat surface (Figure 3).

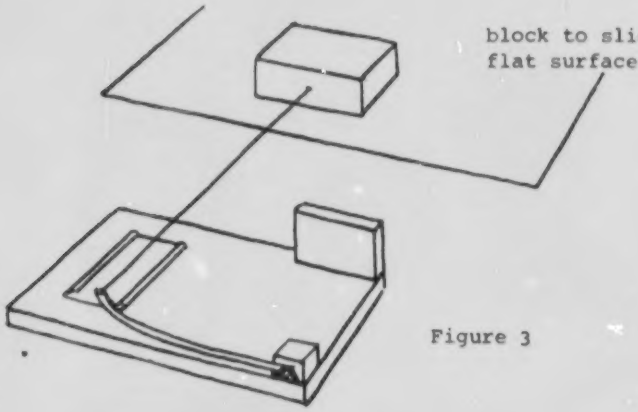


Figure 3

2. Measuring the Force of the Weight of Some Object

Use the FORCE MEASURER to measure the vertical pull of gravity. (Figure 4).

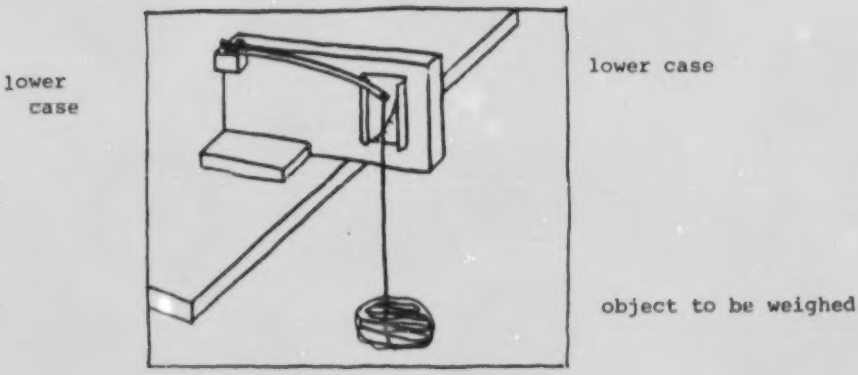


Figure 4

3. Measuring Loss of Weight when a Body is Immersed in a Liquid

Suspend a heavy object, or anything that sinks in water, on a long thread from the blade of the FORCE MEASURER so that the object hangs over the edge of a bench. Record its weight. Now raise a large deep bowl of water up under the object. Notice how the blade deflects less as the object is immersed. Record its weight when:

a) it is partly submerged

b) it is further submerged

c) it is fully submerged

Repeat using a different liquid, eg, kerosene.

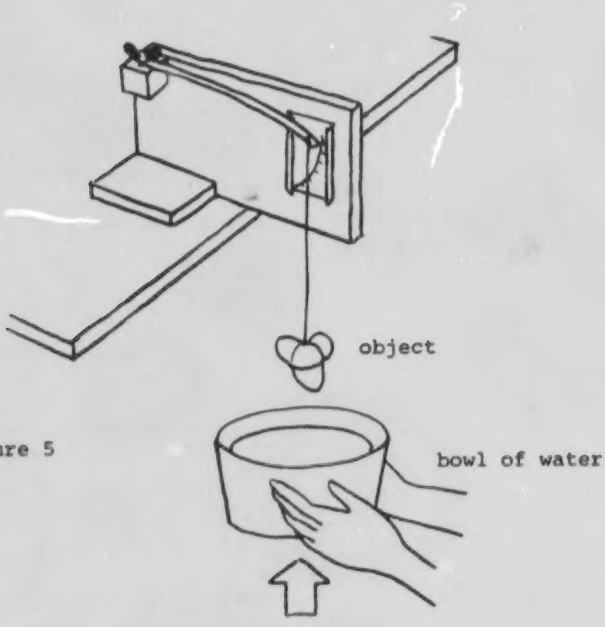


Figure 5

4. Measuring Magnetic Forces

Suspend a bar-magnet by a long thread over the edge of a bench from the blade of a FORCE MEASURER, so that it is not near the metal of the instrument. Now hold another magnet below the first. Is the force one of attraction or repulsion? Does bringing the magnets closer together change the magnetic force? Record the forces at various separations. Reverse the lower magnet. Is the force now one of attraction or repulsion?
Measure the force at the same separations as before.
Is the force the same for the same separation?
How does the magnetic force depend on distance.

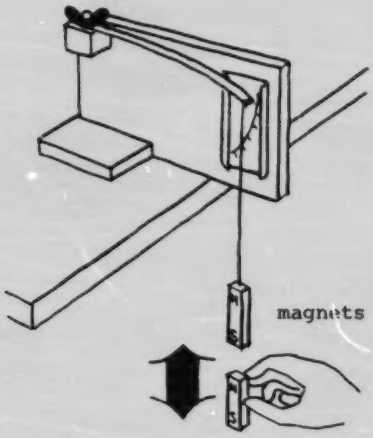
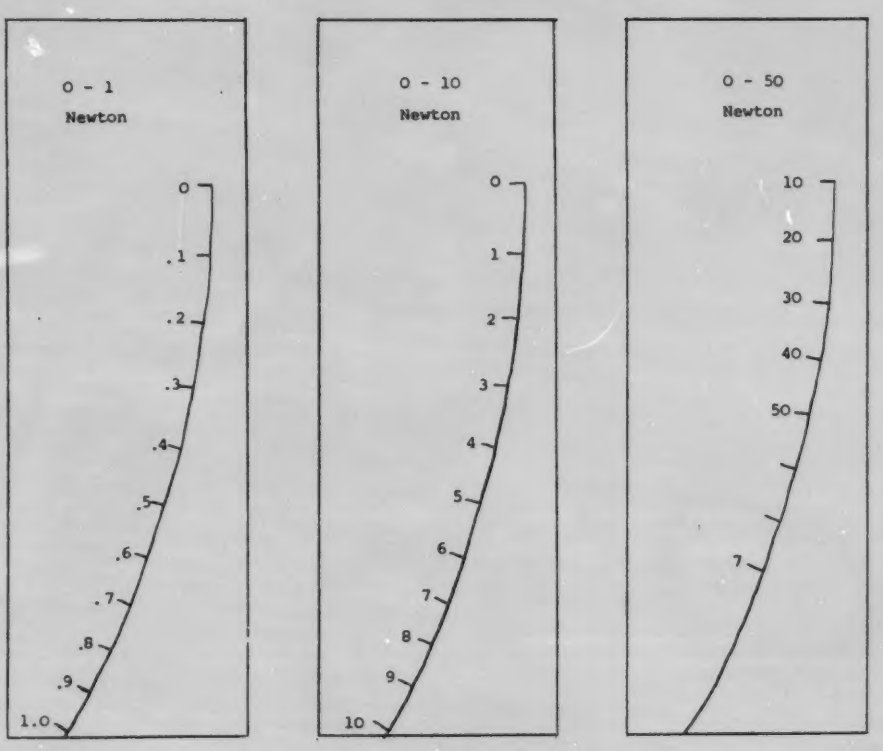


Figure 7

Modification:

The holder for the cardboard scale could be replaced by a scale marked on a piece of card and held with drawing pins.

Sample Scales:



WATER CLOCK

Description:

This is a very cheap and simple device for measuring time.

Objectives:

As a result of making and/or using this device children should be able to:

- explain that a constant flow of water can be used to measure time;
- make measurements of time intervals;
- interpret data from experiments.

Age group

7 - 11 years

Materials:

Two glass bottles of the same size, eg, ink bottles

Two pieces of thin glass tubing

One rubber stopper

Drill

Knife

Construction:

1. Drill two holes through the rubber stopper
2. Cut off the edges of the rubber stopper as shown (Figure 1).
3. Insert the two pieces of glass tubing through the two holes as shown. (Figure 2.) (Hold the glass tubing with a piece of cloth while pushing it through the stopper.)
4. Fill one bottle with water.
5. Fit the rubber stopper to the bottle filled with water.
6. Fit the empty bottle to the other side of the rubber stopper.
7. Invert the apparatus as shown in Figure 3.

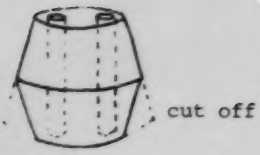


Figure 1

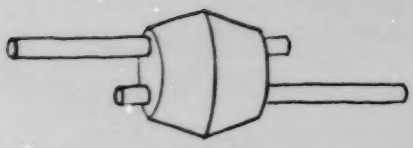


Figure 2

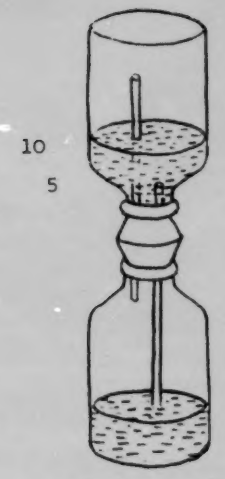


Figure 3

8. Using a watch or clock, time how long it takes for the water to reach a particular level, eg, every 5 minutes.

9. When the markings are completed, invert the apparatus and repeat the procedure with the other bottle.

Use:

The clock can be used to time simple experiments or for measuring short intervals of time.

SIMPLE THERMOMETER

Description:

A low-cost device used to determine temperature by observing the level of ink in a fine tube. The level of ink rises as the temperature increases and goes down as the temperature decreases.

Objectives:

The children are able to:

- explain how a thermometer works;
- construct a simple thermometer;
- use their thermometer to make measurements of temperature;
- compare temperatures.

Materials:

Small-size tube

Used ball pen refill (about 14 cm long)

Rubber stopper to fit the tube

Piece of white cardboard

Piece of thin metallic wire

Wooden block (5 cm x 5 cm x 5 cm)

Alcohol

Red ink

Construction:

Fill the tube with alcohol and add 3 - 4 drops of ink, then shake the tube. Make a hole through the rubber stopper for inserting the ball pen refill. This should fit tightly. Remove the metallic point of the refill. Place the rubber stopper with refill in the tube (the alcohol level in the refill will rise). Now dip the test tube in hot water with a temperature slightly over 40° C (measured by a commercial thermometer) so as to make the alcohol overflow and at the same time close the refill by inserting the metallic point into the top of the refill. Simultaneously seal with wax the joints between the tube and rubber stopper; the rubber stopper and the refill; and the refill and the metallic point. Fix a piece of white cardboard to the refill with wire. Drill a hole in a wooden block so that the tube may be inserted into the wooden block for nearly half of its length. This block will serve as a holder (Figure 1).

Note: While expelling the alcohol and inserting the metallic point, care should be taken to ensure that no air bubbles get into the refill. The same care should be taken when sealing the joints.

Use:

Place the tube in ice-water for calibrating the scale at 0° C. Then dip the tube into hot water whose temperature is 40° C. (Measure this with a commercial thermometer.) Mark the level of alcohol for a temperature of 40° C. Now graduate uniformly from 0° C to 40° C. Any temperature within this range may be reliably estimated with this low-cost thermometer. For example, room temperature and the temperature of water.

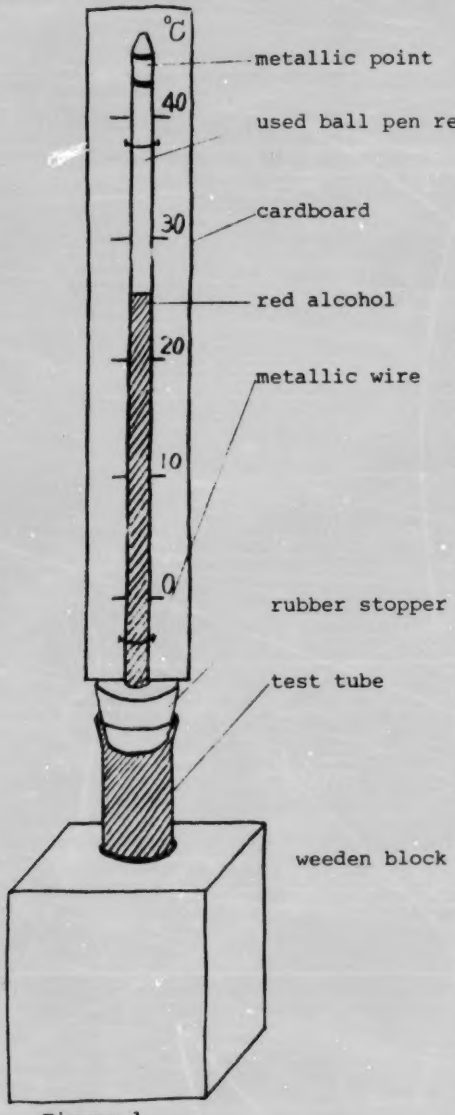


Figure 1

BOX OF BIOLOGICAL TOOLS

Description:

A box of simple biological tools that consists of:

Forceps

Magnifying lens

Mothballs

Needles

Polythene bags

Razor blades

Scissors

Specimen jars

Objectives:

- To enable a student to have access to simple biological tools and to develop basic biological skills.
- To aid a student in the collection and preservation of live specimens.
- To enable a student to study in closer detail the specimens collected or dissected.

A NEEDLE WITH A HANDLE

Materials:

Sewing needle

Piece of soft wood or bamboo stick or plastic material that could serve as a handle.

Construction:

Insert the eye of the needle into the handle. (Figure 1)

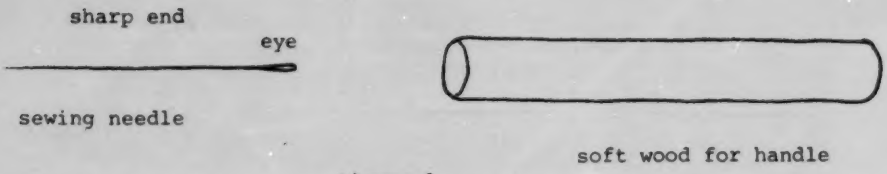


Figure 1

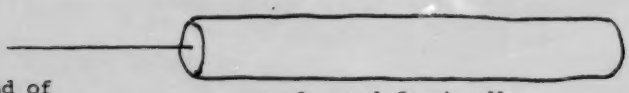


Figure 1

B. FORCEPS

Materials

Bamboo

String or strong thread

Construction:

Take 2 pieces of bamboo 16 cm long, 2 cm wide and 0.5 cm thick. (Figure 2.)

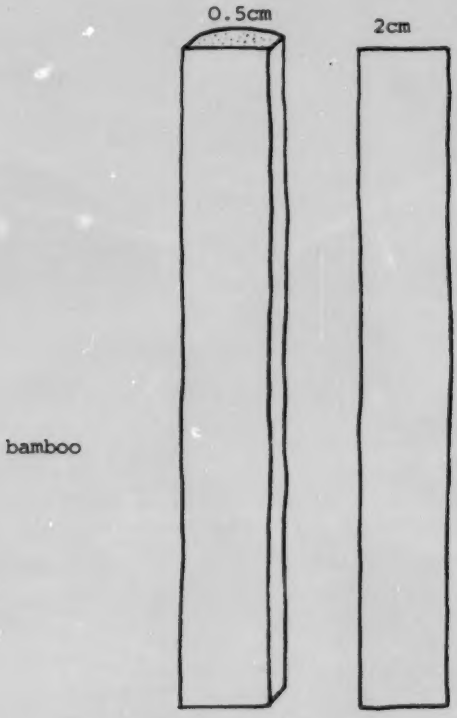


Figure 2

Sharpen one end of both these pieces. (Figure 3)

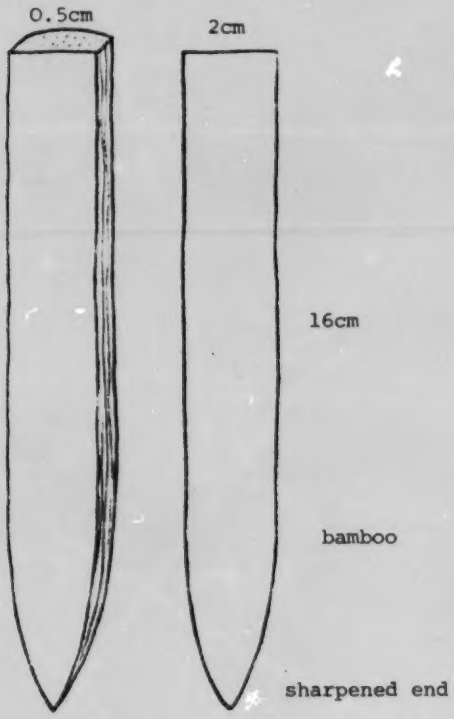


Figure 3

Cut a small piece of wood 3 cm long, 2 cm wide and 1 cm thick. (Figure 4)

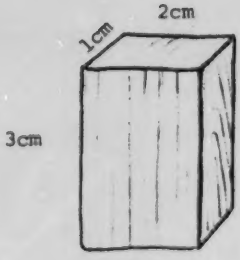


Figure 4

Place the small piece of wood 3 cm by 2 cm between the 2 bamboo pieces. At the unsharpened end tie them together as shown in Figure 5.

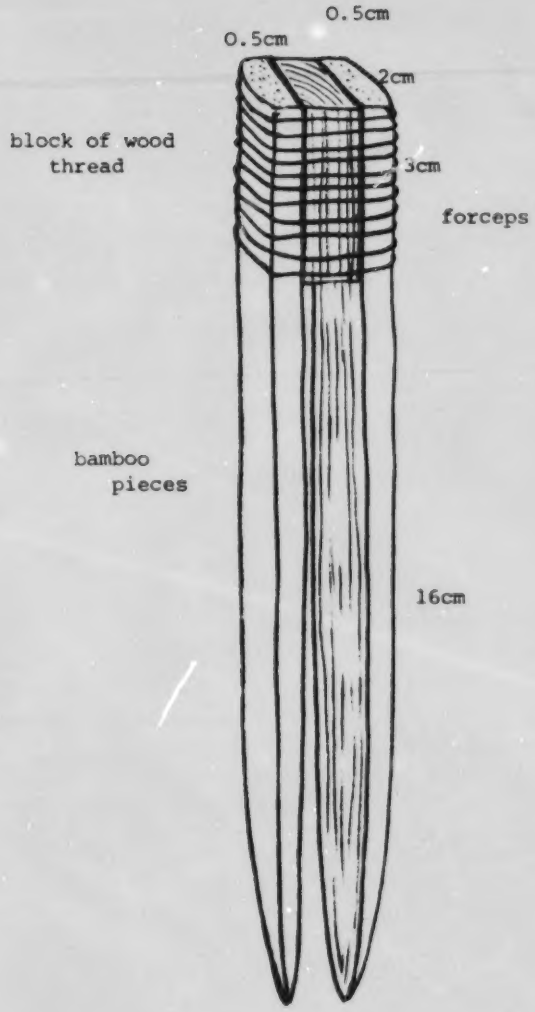


Figure 5

C. MAGNIFYING LENS

Materials:

A used bulb

Water

Construction:

Remove the metal contact and filament from a used bulb (Figure 6).

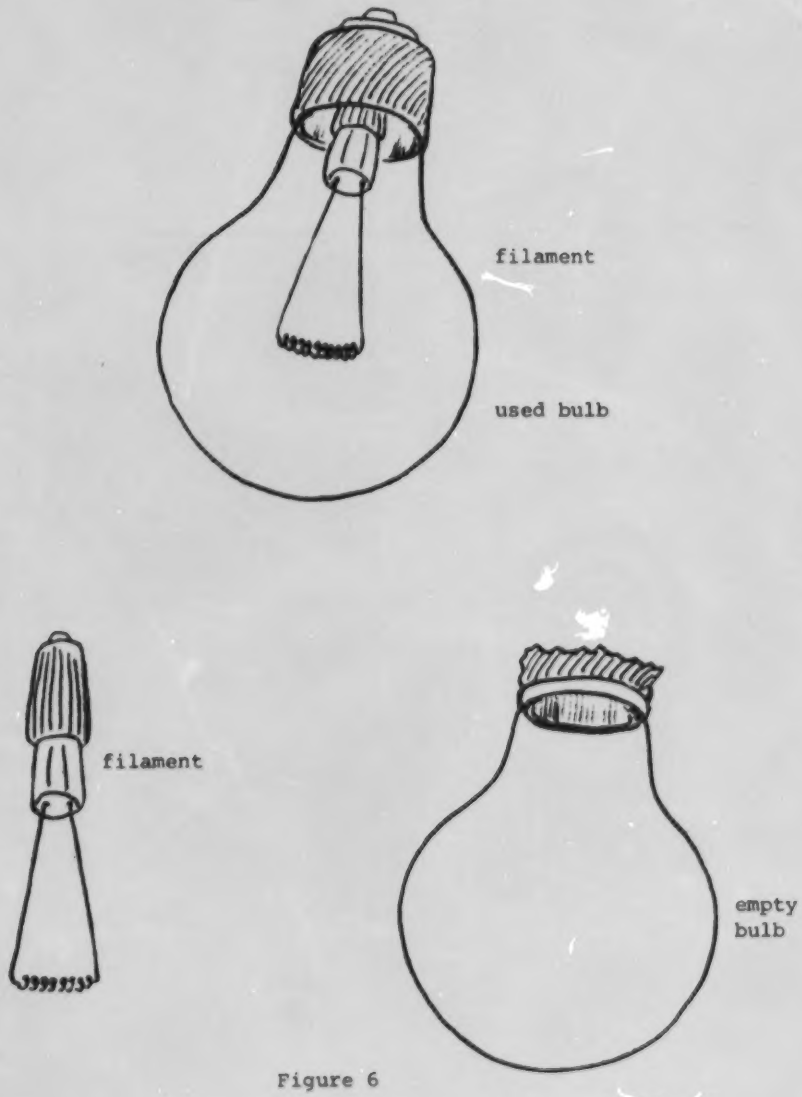


Figure 6

Fill the empty bulb with water (Figure 7).

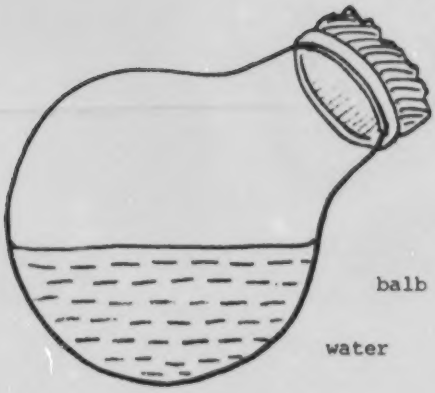


Figure 7

Use:

This is a very simplified magnifying lens that can be used by holding it at a suitable distance from the object being studied.

D. SPECIMEN JARS

Materials:

Small transparent bottles with lids, eg, jam bottles, medicine bottles.

Construction:

Place the specimen in a bottle

Place a drop of water in the bottle

Make a few holes in the lid before closing the bottle.

E. POLYTHENE BAGS

Materials:

Polythene bags collected by students.

Use:

Keep the air in the polythene bags moist by adding a few drops of water. Insect or plant specimens can be kept in these bags.

F. RAZOR BLADES WITH HANDLE

Materials:

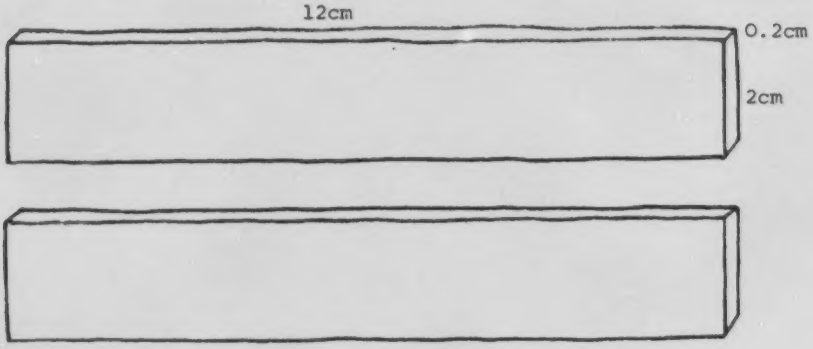
Razor blades

2 pieces of soft wood, or 2 pieces of hard cardboard.

Small pieces of wood to be used as wedges.

Construction:

Cut 2 pieces of softwood or hard cardboard 12 cm in length, 2 cm wide and 0.2 cm in thickness.



softwood or hard cardboard

Figure 8

Cut holes into the wood or hard cardboard corresponding to those in the blade (Figure 9).

holes

Figure 9

Place the blade between the two pieces of cardboard or soft wood pieces and plug pieces of wood into the holes (Figure 10).

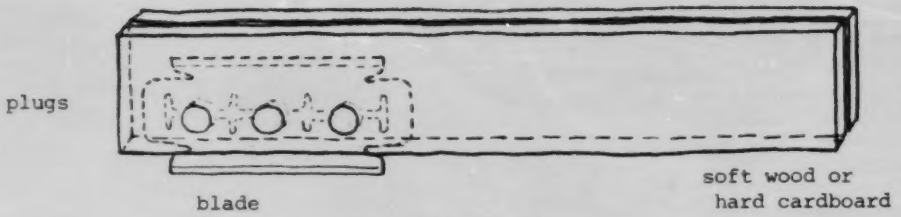


Figure 10

Use:

This simple device can be used for any activity that requires a simple cutting device.

G. MOTHBALLS

These could be included in the biological kit for the preservation and maintenance of the biological box of tools.

H. SCISSORS

This is an essential item used in many activities to develop biological processes and skills.

PLANT PRESS

Objectives:

The students can:

- press leaves/plants for the preparation of a herbarium;
- develop an interest in the leaves and plants in their local environment;
- study the different leaves/plant specimens in their local environment

Materials:

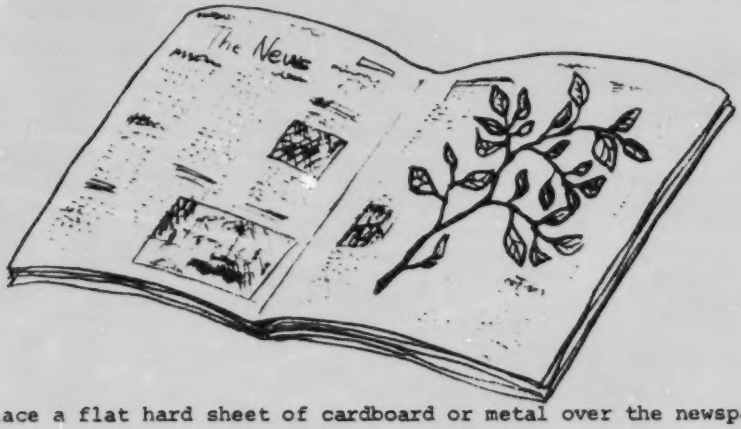
Old newspapers

Any flat hard sheeting, eg, cardboard, metal

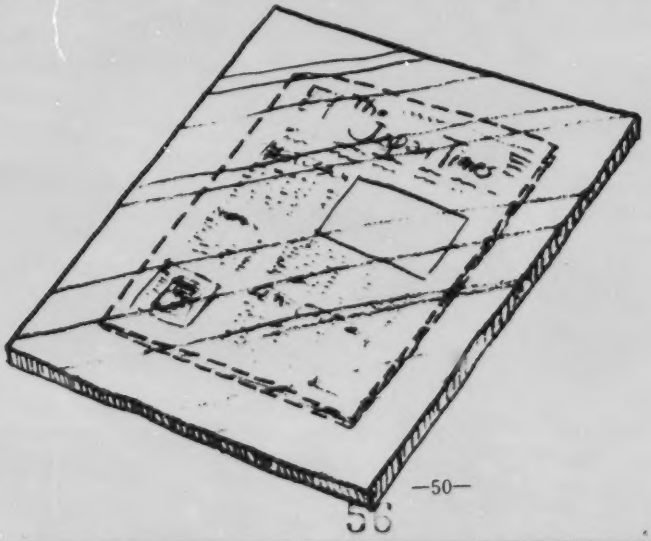
Any heavy object

Construction:

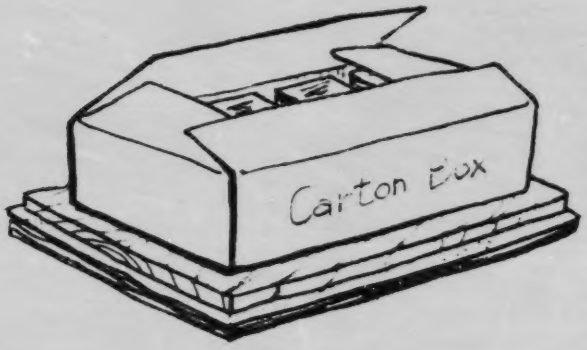
Place the leaves and plants carefully between sheets of an old newspaper.



Place a flat hard sheet of cardboard or metal over the newspaper.



Place a heavy object over the sheet of cardboard.



Leave aside for a few days.

Uses:

1. The pressed plants can then be mounted on card and can be used for identification.

2. Categorization of the pressed plants could be left to the teacher or children may carry out research to find their names.

A SIMPLE STETHESCOPE

Description

A device for listening to heart beats.

Objectives:

The students can:

- listen to heart beats of humans;
- find out that heart beat rate increases after physical activity.

Age group: 8+ and onwards

Materials:

90 cm of soft plastic tube (0.75 cm diameter)

A 'Y' tube made of plastic or glass

A small funnel or used ice cream cup or similar cup made of plastic

Rubber balloon

Cellotape/thread

Watch or clock

Construction:

Cut 10 cm of plastic tube and attach it to the stem of the funnel (Figure 1). Alternatively obtain a plastic container and make a hole in the base slightly smaller than the diameter of the tube. (A hole can be made with a hot needle and widened with a file.) Insert the tube into the hole (Figure 1).

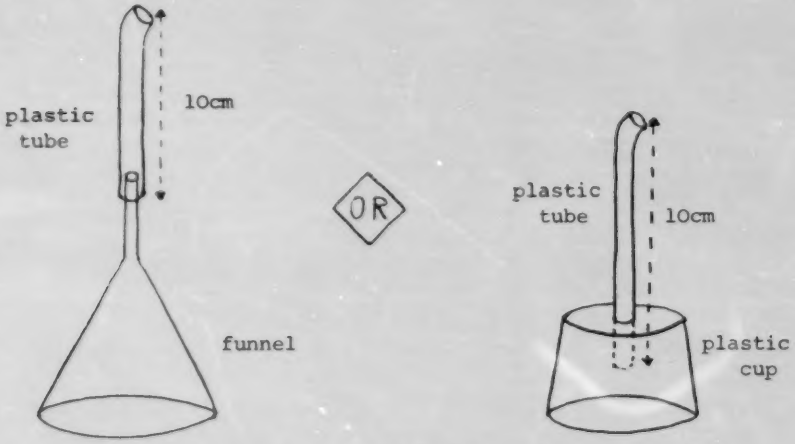


Figure 1

Divide the remaining portion of the tube equally into two halves. (Each half will be around 40 cm in length.) Attach these two pieces to the two ends of a 'Y'-tube. The other end of the 'Y'-tube should be fitted to the free end of the plastic tube attached to the cup/funnel (Figure 2).

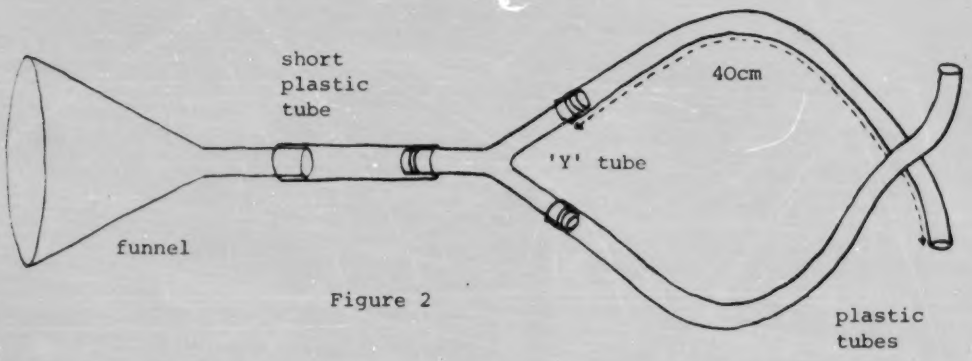


Figure 2

Cut the balloon and stretch the rubber over the mouth of the funnel/cup. Bind with cellotape or thread (Figure 3).

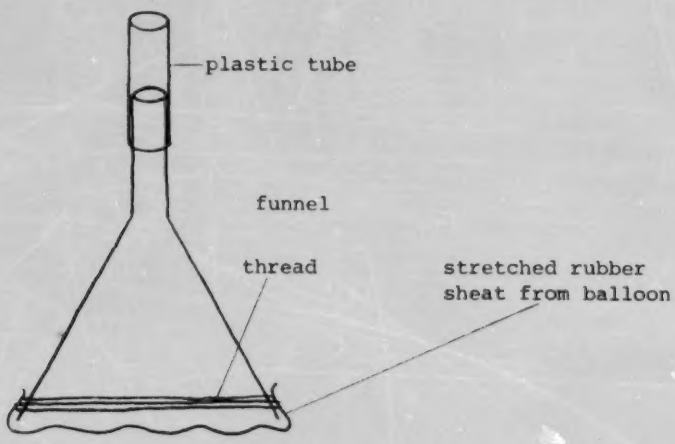


Figure 3

Use:

1) Place the two free ends of the plastic tubes in each ear and place the funnel/cup gently on the lower part of the chest on the left side. The heart beats will be heard clearly. Count the number of beats per minute and record.

2) After exercising count the number of beats per minute again. Record any difference between the number of heart beats per minute before and after exercising. (By doing physical activity while running, heart activity increases resulting in a greater number of heart beats within a fixed period of time.)

BREATHING SYSTEM

Description:

The apparatus demonstrates/teaches the operation of the human lungs.

Objectives:

The children can:

- explain how animals and humans breathe;
- use a model to show the breathing system.

Materials:

Transparent plastic bottle, or any other suitable cylinder - must be rigid

Y-shaped plastic tube

Balloons

Cellotape or string

Plasticine

Construction:

Make a hole, as big as the stem of the Y-tube at the centre of the closed surface of the transparent plastic bottle (Figure 1).

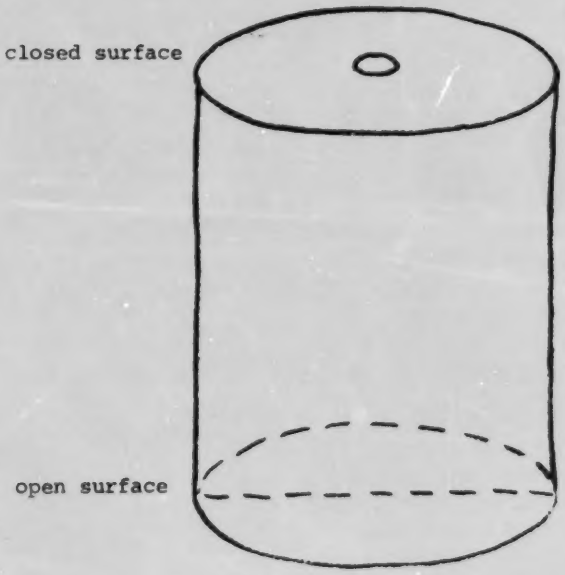


Figure 1

Transparent Plastic Bottle

Fix a balloon at each end of the Y-tube and tie each firmly with string (Figure 2).

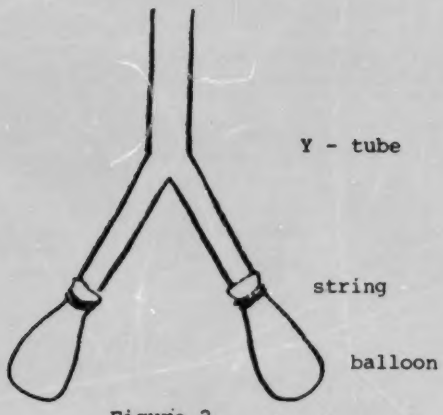


Figure 2

Insert the stem of the Y-tube through the hole at the centre of the closed surface of the plastic bottle and keep this in place using plasticine.

The opened end of the transparent plastic bottle is covered with rubber sheeting tightly secured with string and cellotape.(Rubber sheeting could be obtained by cutting a big balloon into two).

The apparatus should be air-tight.

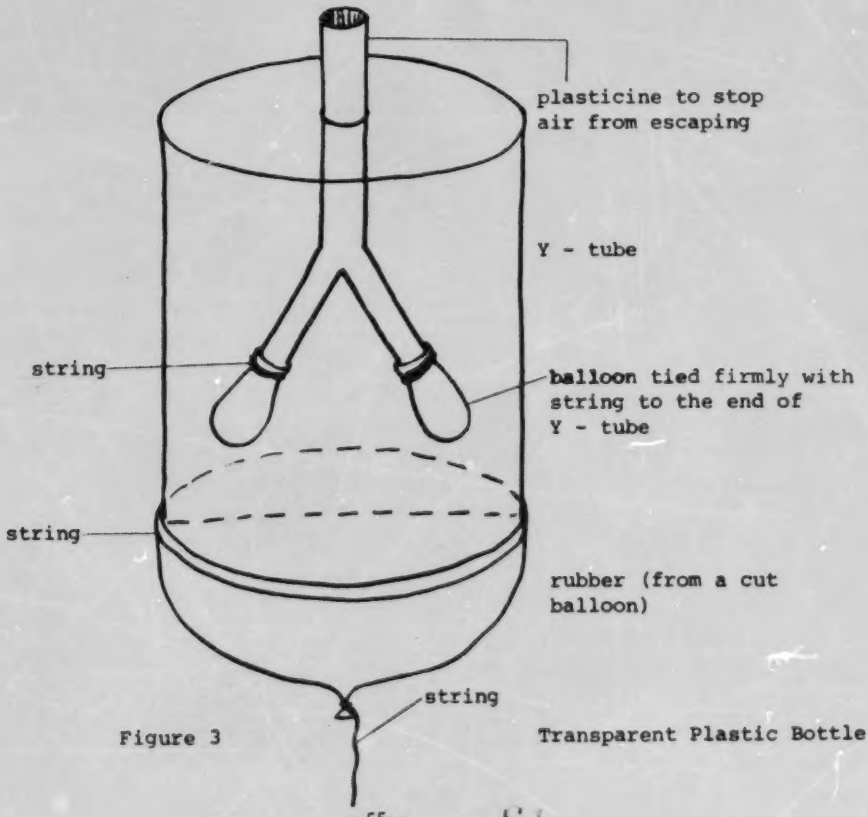

plasticine to stop air from escaping
Y - tube
string
balloon tied firmly with string to the end of Y - tube
string
rubber (from a cut balloon)
string

Figure 3 Transparent Plastic Bottle

81

Use:

1. When the rubber sheeting at the bottom end of the breathing chamber is pulled downwards, the balloons in the cylinder will expand. This shows that air has moved into the balloons.

2. When the rubber sheeting at the bottom is released, the balloons attached to the ends of the Y tube decrease in volume. This shows that air has moved out of the balloons.

3. These activities show the idea of breathing in and out, through the lungs, by humans and animals.

SIMPLE POTOMETER

Description:

A device for showing that water is absorbed by plants.

Objective:

The children can explain and demonstrate that water is absorbed by plants.

Materials:

2 plastic tubes A and B, diameter 2 cm, length 30 cm

2 thin plastic tubes diameter 2 mm, length 10 cm.
(Empty refills of ball point pens are suitable.)

4 cork plugs

Grease or petroleum jelly

String or wire

Wooden board

Strips of graduated thick paper

Construction:

Bend the plastic tubes A and B into a U-shape and fix them into the piece of wood with wire or string (as shown in Figure 1 and 2).

Put the thin plastic tubes (ball point refills) into hot water and bend them into L-shapes.

Fit the L-shaped tubes to one end of the plastic tubes A and B respectively using cork plugs; (as shown in Figure 1 and 2).

Use:

1. Fill the plastic tubes A and B with water until the water fills up the thin bent tubes as well.

2. Fix a shoot of a small plant into one arm of the plastic tube (A) using cork plugs.

3. Fix a cork plug into tube (B).

4. Grease all the plugs to avoid water leaks.

5. Place the two sets of apparatus on a flat table away from draughts.

6. Compare the movement of the water surfaces in the tubes of both apparatus to confirm that water is absorbed by the plant.

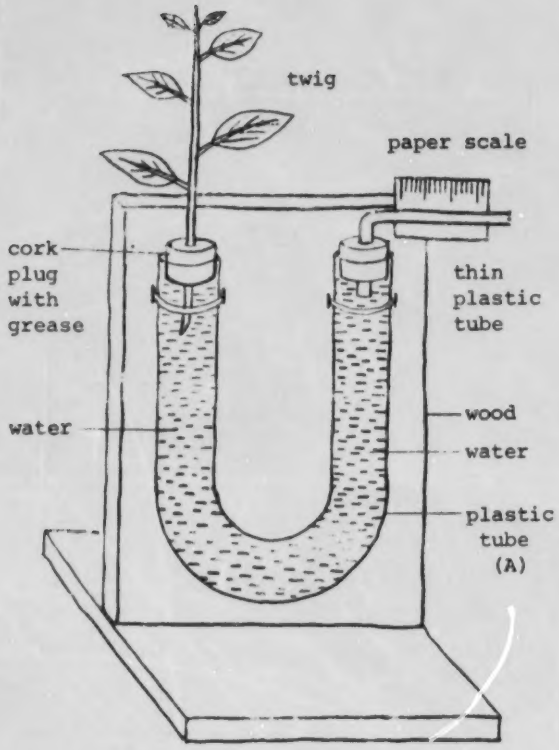


Figure 1

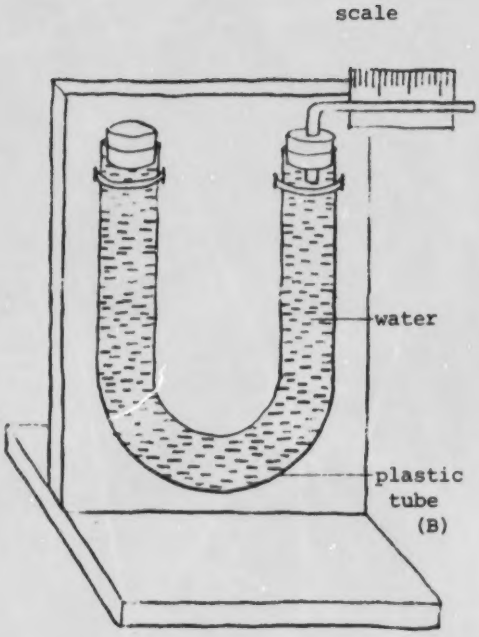


Figure 2

TRANSPIRATION BY PLANTS

Description:

A simple device for demonstrating that plants give off water vapour during transpiration.

Objectives:

On completing this activity students should be able to:

- observe and explain transpiration as an important life process of plants around them;
- show that transpiration involves giving off water vapour from plants;
- observe and explain that under differing conditions of temperature and area of transpiring surfaces (viz. leaves) the rate of transpiration varies.

Age level: 9+ years old and above.

Materials:

Two plants having large leaves (more or less of the same variety, height and age) growing in pots

Polythene (plastic) bags

Thread/rubber bands

Construction:

Take the pot plants and place them side by side. Remove all the leaves from one plant. Cover shoots of both plants (one with leaves and one without) with clean, dry polythene bags of a suitable size and close the mouth of the bags tightly with threads or rubber bands.

Observe the bags after 1 - 2 hours. (The bag containing the plant shoot with leaves should become foggy with water drops accumulating on the inner surface of the bag whereas the other bag, with a shoot devoid of leaves, remains as it is.) Figure 1)

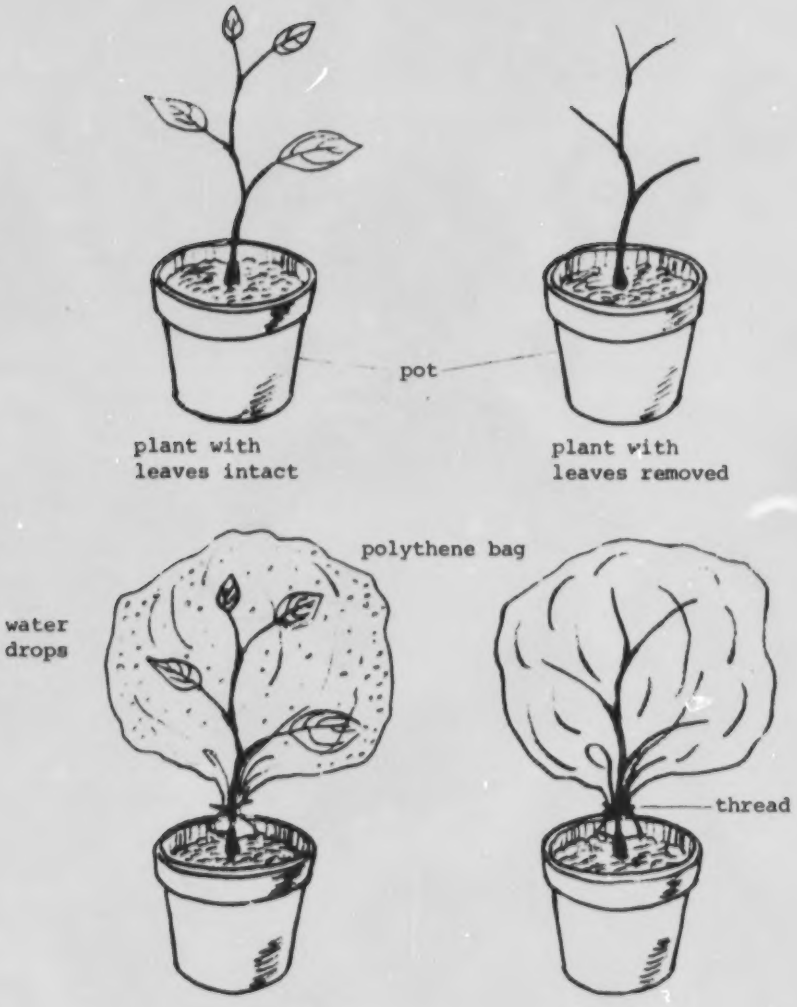


Figure 1

Transpiration of Water Vapour by Plants through Leaves

Place the pot plant with leaves inside a fresh, clean, dry bag in a room and note the time required for the bag to become completely foggy. Find out the time required for the bag to become completely fogged when the pot is kept in direct sunlight. Similarly note the time for the plant having (i) all the leaves intact (ii) about half of the leaves removed and (iii) a few leaves only.

(The pot will have to be kept at the same place.) What do you observe? (The plant gives off water vapour more quickly in direct sunlight due to the higher temperature. Similarly transpiration rate diminishes by reducing the area of transpiring surfaces by removal of leaves).

Modifications:

In the absence of pot plants the pupils may carry out the experiment by enclosing suitable branches of garden plants, with large leaves, in polythene bags. Use the same method as noted earlier. The plant will have to be watered well to get quick results.

EFFECTS OF TEMPERATURE ON FLIES

Description:

A simple laboratory device which demonstrates the effects of varying temperature on the survival and activity of small living organisms.

Objectives:

On completing this activity children should be able to:

Concepts

- explain that living objects are affected by varying conditions of temperature;
- explain that every organism has minimum and maximum limits of tolerance with regard to temperature;
- state that there are preferred conditions under which an organism lives.

Skills

- use science processes such as prediction, formulation of hypotheses, planning an experiment, organisation and interpretation of data.

Age level: 10+ years.

Materials:

Bottles, 2 with one holed stoppers. Large jar.

Thermometer

Two sets of wooden pieces each with semicircular holes cut out of the middle. (The wood pieces must be long enough to rest on the jar when tied together. They have a circular hole in the centre. The hole must be just large enough for holding the edge of the bottle mouth so that the bottle hangs in the water of the large jar.) See Figures 1 and 2.

30 - 40 fruit or house flies

Construction:

1) Place an equal number of flies of the same kind in the two bottles. Close each one with the 1-holed stopper. Insert the thermometer in the stopper hole. Mark one bottle A and the other bottle B. Note the temperature in each bottle. Observe the activity of the flies at this temperature.

2) Submerge bottle A up to its neck in the big jar filled with water. Support the bottle with the help of the wood pieces. (Figure 1 and 2)

Use:

1) Raise the temperature in bottle A by adding hot water slowly to the big jar. Stir while adding.

2) Observe the activity or condition of the flies in this bottle A. Compare this with the activity or condition of the flies in bottle B.

3) Note the temperature when the flies in bottle A start showing signs of collapse.

4) Find out whether the flies revive after collapse by bringing the temperature down to the normal room temperature.

5) Record the effects of different temperatures on the activities of flies in a tabular form.

EFFECT OF TEMPERATURE CHANGES ON FRUIT FLIES

	Temperature °C	Activity or condition of flies
Bottle A		
Bottle B		

6) Find out the highest temperature at which flies behave normally. Identify also the temperature at which the flies live most favourably.

7) Suggest a procedure to be adopted for finding out the lowest temperature at which the flies could behave normally.

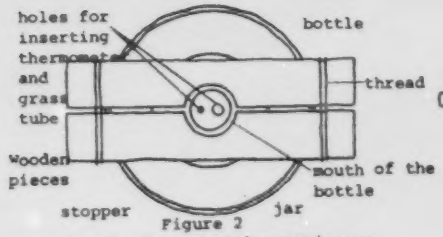


Figure 2

Mouth of the bottle resting on wooden plank kept on big jar (surface view)

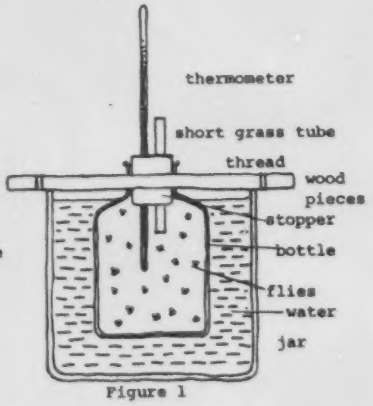


Figure 1

Apparatus to demonstrate effect of varying temperature on flies

EXPANSION OF LIQUIDS OR GASES BY HEAT

Description:

This device demonstrates how substances expand and contract when heated and cooled.

Objectives:

Processes and skills that can be developed include:

- observing
- collecting and recording data
- interpreting data
- measuring
- predicting
- forming conclusions.

Age group: 11+ years old.

Materials:

Bottle, glass or plastic with narrow neck

Colouring material, eg, ink or dye

Cork or rubber stopper to fit the neck of the bottle

Tubing, about 2 - 5 mm diameter and 10 - 15 cm long. (The inside or outside tubes of a ball point pen would be suitable. Glass tubing would also be suitable.)

Sources of heat, eg, burner, water bath, sunlight, etc.

Construction:

Make a hole in the cork so that the tube fits tightly.
Suggestion: Wet the cork before making the hole.
Use a nail or other sharp object to make the hole.

Fill the bottle to the top with liquid (water or oil).

Put the cork in the bottle as shown in Figure 1.
Make sure there are no bubbles in the bottle.

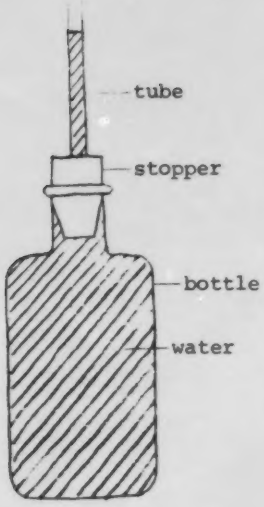


Figure 1

Use:

A. Expansion of liquids

1 Mark the level of liquid in the tube.
2 Heat the bottle by either:
- holding above a lighted spirit lamp
- placing in hot water
- " " sunlight
3 Mark the new level of liquid in the tube
4 Reheat using hotter or colder heat sources

B. Expansion of gas (air)

1 Empty the liquid from the bottle but keep some liquid in the tube (as shown in Figure 2)
2 Heat the bottle by:
- holding hands around the bottle
- placing bottle in sunlight
- " " in hot water

Modifications:

(a) The device could be used to demonstrate and teach the principle of a thermometer; and to teach the use of a scale.

(b) The device could be used to compare (and measure) the different expansions of different liquids. Children could make predictions, collect and record data, tabulate it and possibly make a graph.

(c) The device can also be used to demonstrate different rates of heat absorption by shiny or blackened surfaces if the sides of the bottle are wrapped in metal foil or blackened with paint, or rubbed with charcoal or soot.

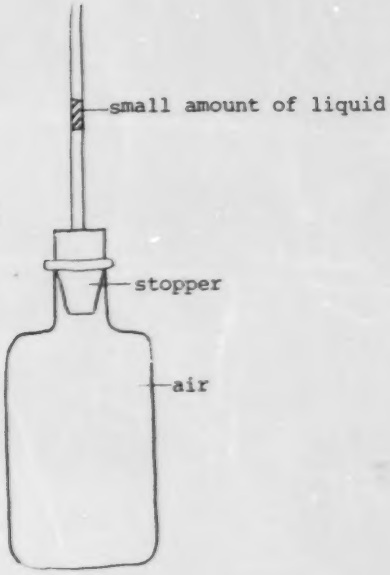


Figure 2

MELTING OF SOLIDS WHEN HEATED

Description:

This device enables the student to observe the differing melting points of a number of solids.

Objectives:

Processes and skills that could be developed include:

- observing
- collecting and recording data
- interpreting data
- predicting
- forming conclusions

Age level: 9+ years old.

Materials:

- Samples of a number of different solids, eg, wax, solder, iron, camphor or naphthalene, salt, sugar, plastic, agar, soap
- Spirit burner or candle
- Tin can lid (approximately 10 cm diameter)

Construction:

Using a metal rod or round-headed hammer make a number of small depressions in the lid (as shown in Figure 1). Be sure that each depression is about the same distance from the edge of the lid.
Each depression should be about 1 cm in diameter and 0.5 cm deep.

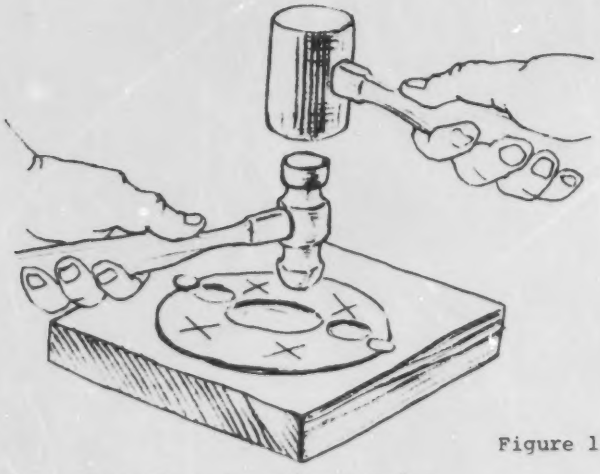


Figure 1

X = Locations for other samples

Use:

1. Rest the lid on a stand (or between two supports) as shown in the diagram (Figure 2).

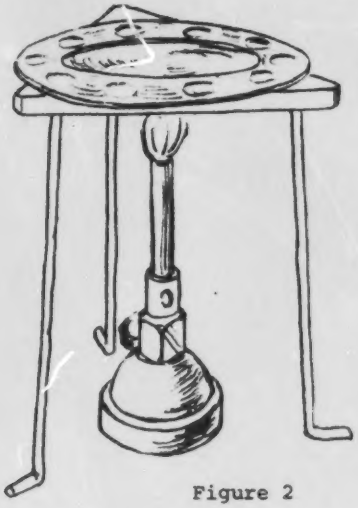


Figure 2

2. Place small samples about the size of a rice grain, of different substances, in each depression.

3. Gently heat the lid with the flame at the centre and make observations.

4. Record the changes in each solid as it is heated.
(They will melt at different times because of their differing melting points.)

KIT FOR SHOWING CHANGE FROM SOLID/LIQUID/GAS AND PROPERTIES OF SOLUTIONS AND MIXTURES

Description:

This kit can be used to demonstrate or teach the following:

- change of water as a gas into water as a liquid;
- constant or fixed melting temperature of ice and freezing point of water;
- constant or fixed boiling temperature of water;
- the separation of the different parts of a solution.

Objectives:

Processive skills that could be developed include:

- observing
- measuring
- collecting and recording data
- interpreting data
- forming conclusions
- skills in designing an experiment in which variables are controlled
- plotting or drawing a graph
- predicting.

Age level: 10+ years old

Materials:

- Container (any size) or beaker. The container could be the bottom half of a plastic bottle, or a tin, bottle, etc.
- Cloth or tissue
- Funnel (any size). This could be made by cutting off the top part of a plastic bottle (See Figure 1).

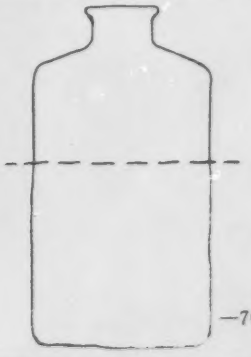


Figure 1

Ice, salt, sand or soil

Spirit burner

Tube holder, eg, test-tube holder, or holder made from bent wire or folded paper

Small tube, or test-tube. The tube could be a pill tube from a clinic.

Construction:

The only items that need to be made are the funnel and the container. These can both be made from a narrow-mouthed plastic bottle (see Figure 1).

Use:

A. Changing a gas into liquid

1. Using cloth or tissue dry the mouth of the tube. Close the mouth of the tube with a piece of tissue or cloth (or cork or foam).

2. Put the tube into the container.

3. Pack a mixture of ice and salt around the tube. (Figure 2)

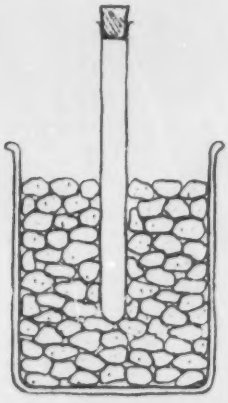


Figure 2

4. Leave for 2 - 5 minutes.

5. Quickly take the tube out and wipe dry. Observe the inside of the tube (the inside should be covered with drops of water).

B. Fixed freezing point of water

1. Put the funnel into the container (see Figure 3).

2. Place the thermometer into the tube and add no more than 1 cm of water to the tube.

3. Place the thermometer and tube into the funnel and pack ice and salt mixture around it.

4. Observe and record the temperature until the temperature stays fixed or constant for about 5 minutes.

5. Remove the tube from the ice, wipe dry and observe.

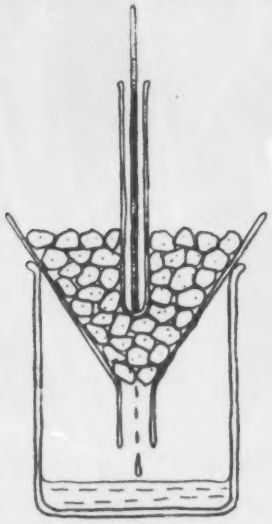
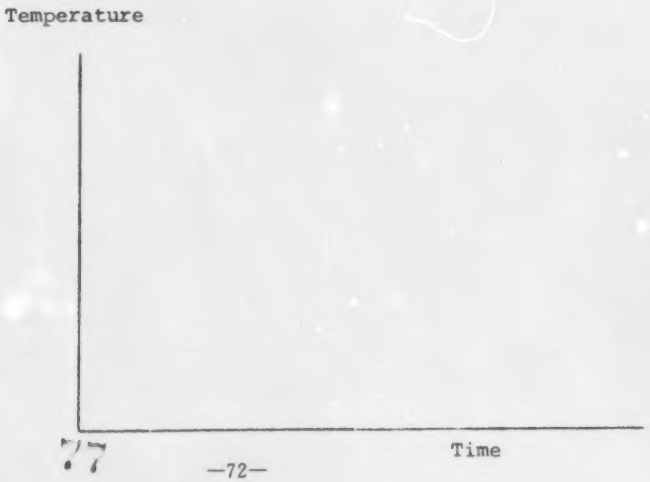


Figure 3

6. Students could draw a simple graph of temperature against time.



C. Fixed melting point of ice and boiling point of water

1. Place small pieces of ice in the tube and carefully insert the thermometer. Observe and record the temperature. (Figure 4)

2. Carefully and gently heat the tube with the spirit burner. Observe and record the temperature at regular times during the next 15 minutes. (Ice must be heated until the resulting water boils.)

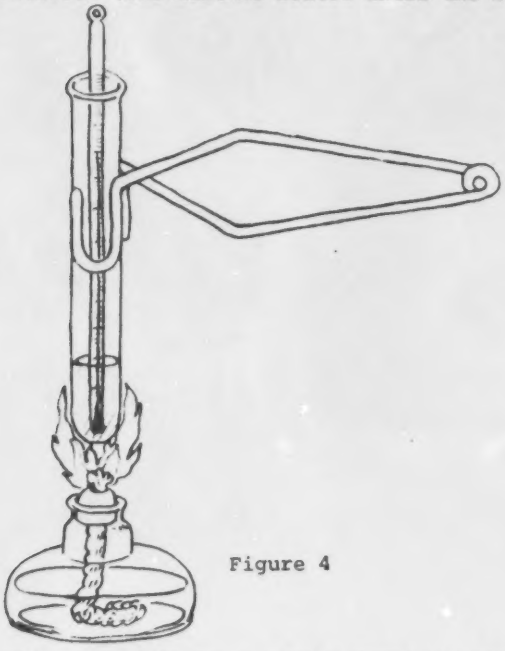
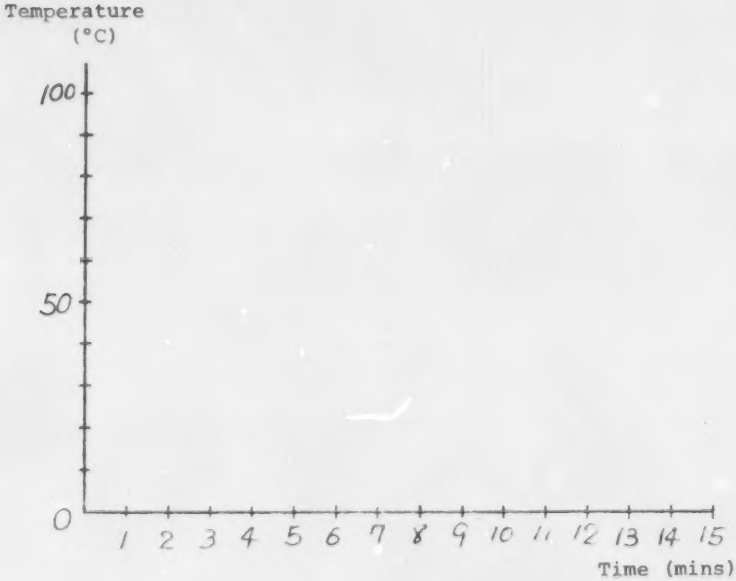


Figure 4

3. Students could draw a simple graph of temperature against time.



D. Separating the parts of a solution

1. Using a solution of salt and water

   (a) Mix together some salt and water to form a clear solution. (Have students predict how the salt may be recovered.)

   (b) Put a little solution into the container and heat to boiling. While boiling hold the tube in the steam and show that water can be recovered. (This separates water from salt-water solution. Continue boiling until dry. This recovers salt from the salt-water solution.

2. Using a mixture of water and sand

   (a) Mix together some water and soil to make a mixture in which the water is cloudy or dirty.

   (b) Put the funnel into the beaker and pack tissue or paper into the neck (see Figure 5).

   (c) Pour dirty water into the funnel and collect filtered water.

E. Using salt-water solution to preserve eggs

1. Additional materials: 4 eggs (fresh) and an extra container.

2. Make a salt-water solution of 1 part salt to 5 parts water, eg, 1 cup salt - 5 cups water.

3. Place some salt-water solution in each container enough to completely cover an egg. It will be necessary to place a stone or some heavy object on the egg to keep it under the surface.

4. The third and fourth eggs should be left in the air. Put a mark on the side of these eggs.

5. One week later:

   Remove the egg from one of the containers and boil this egg, and one of the eggs from in the air, and after cooking break open and taste.

   Which egg is the freshest? the most salty?
   After another week take the remaining egg from the salt-water solution and again cook this egg and the egg in the air.
   Again taste the cooked eggs.

Modifications:

1. In part D the solutions could be distilled using simple distillation equipment (see Figure 6).

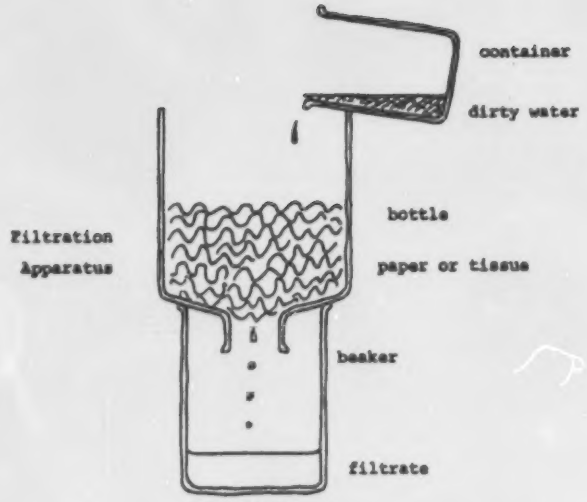


Figure 5

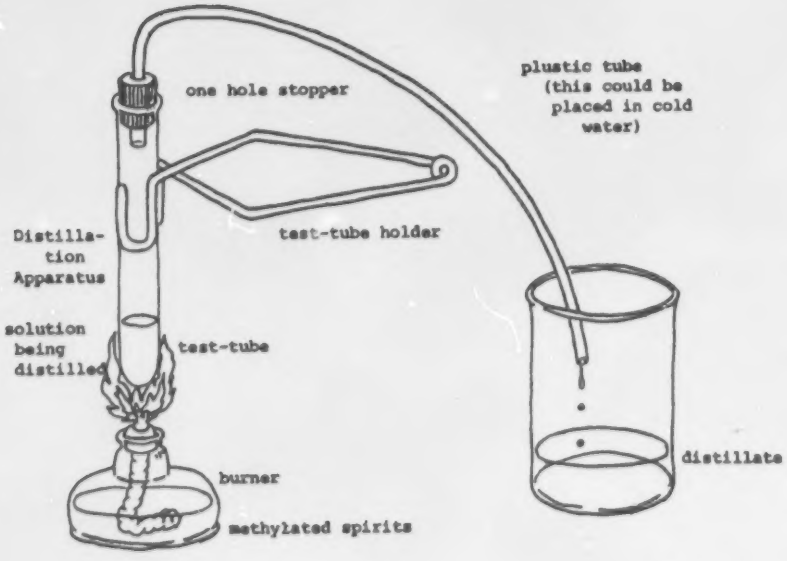


Figure.6

80

BUOYANCY

Description:

This activity should enable students to understand how the mass and volume of a substance determines whether it sinks or floats.

Objectives:

Processes and skills that could be developed include:

- observation
- recording data
- predicting
- forming generalisations.

Age level: 9+ years old

Materials:

Aluminium foil or silver wrapping paper

Ball point pen outer cases (2)

Bottle, glass or plastic, approximately 500 ml

Plastic tubing (about 50 - 100 cm long)

Rubber stopper or cork, 2 holes

Tank, bucket or aquarium

Construction:

1. Make two holes in the stopper to tightly fit the plastic outer case of the pens.
2. Connect the plastic tube to one of the pens (as shown in Figure 1). Make sure the tube fits tightly by tying if necessary.

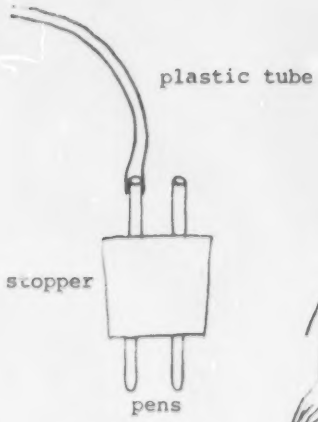


Figure 1

Blow on the tube to make your submarine rise. Let water go into the submarine to make it sink.

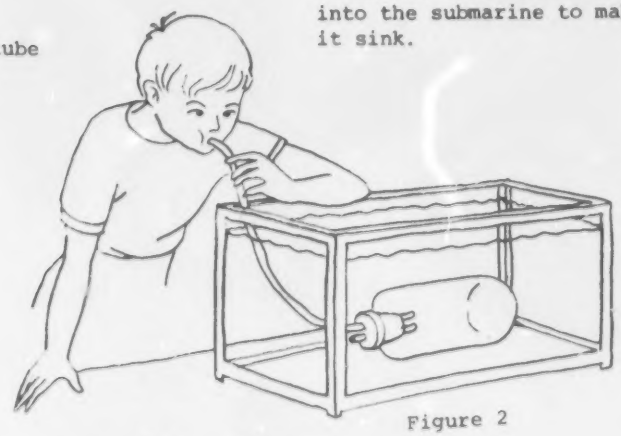


Figure 2

Use:

A. 1. Fill the tank or bucket 3/4 full of water.

2. Place the bottle in the tank and allow it to fill with water. (Push under water if necessary).

3. Blow air into the bottle as shown (Figure 2). Observe what happens.

B. 1. Make several model boats or rafts from the metal foil.

2. Float these in the tank and observe.

3. Carefully add water to each boat or raft and observe what happens.

4. Crumple (or crush) each boat or raft into a tight ball and again attempt to float each ball.

ELECTRICITY KIT 1

Description:

A kitset of materials for use by teachers and children for activities on electrical circuits. Age group 7 - 12 years.

Objectives:

Content

Use of this kitset should enable children to:

- explain that for electricity to flow in a circuit the circuit must be made up of conductors;
- explain the action in a circuit of a switch, a fuse, a resistor;
- discuss series and parallel circuits;

Process skills

Use of this kitset should enable children to:

- read and draw simple circuit diagrams;
- draw symbols for battery, bulb, switch, fuse, resistor;
- construct a simple circuit to light a bulb;
- classify materials as conductors or insulators;
- construct series and parallel circuits;
- experiment to find the effect of various resistors in a circuit.

Attitudes

Through using this kitset children should:

- develop curiosity about the nature of electricity;
- discuss the dangers of electricity;
- realise the need for conservation of electricity.

Materials:

Battery

Battery holder

Bulbs

Bulb holders (2)

Connecting wires

Crocodile clips

Switches - simple
- two way

Resistors

Resistor/conductor holder

Materials for Construction:

Brass pieces

Cardboard tube or bamboo

Drills

Hammer

Nails

Screws

Wood, acrylic or perspex

Construction:

A. Batteries

These will have to be bought.

Used batteries may be available from various sources, eg, Telephone Exchanges, security firms.

B. Battery holder

Any one of the following could be used:

Use a piece of bicycle tube or rubber bands to hold wires in place (Figure 1

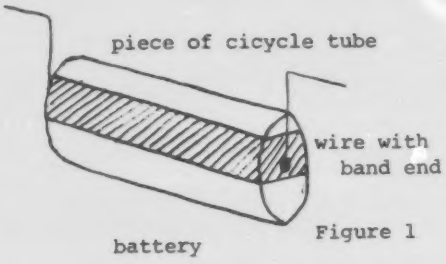


Figure 1

Place batteries in a bamboo or cardboard tube and hold in place with tape or rubber bands (Figure 2).

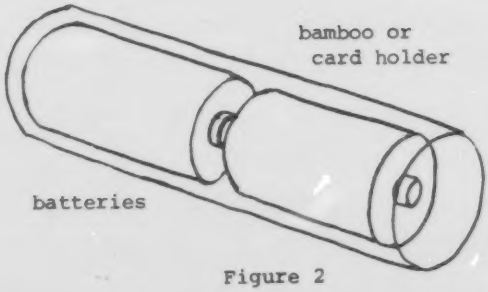


Figure 2

Make a holder using wood and brass (metal) strips as described below:

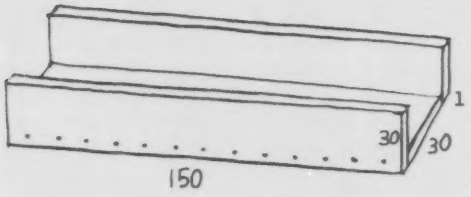


Figure 3

Obtain three pieces of wood approximately 15.0 cm x 3.0 cm x 1.5 cm. Do not assemble at this stage. Prepare two pieces of brass sheet approximately 0.5 mm thick as contacts for the battery. Make indentations in them for contacts.

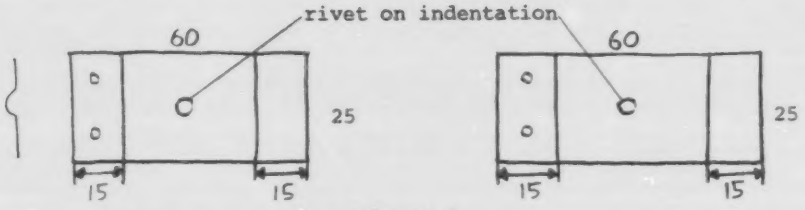


Figure 4

Bend the contacts as shown and then screw to either end of the wooden holder. The distance between the contacts should be the length of two batteries. Wires can be inserted under the contacts and held by the screws. Now nail on the wooden sides. These keep the batteries in position.

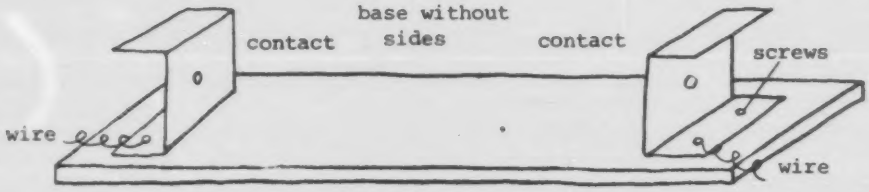


Figure 5

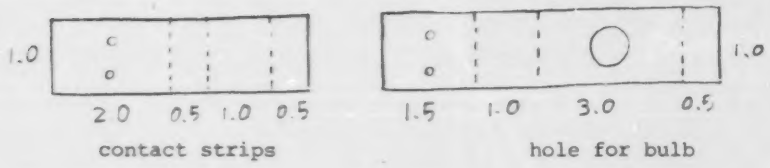
C. Bulbs

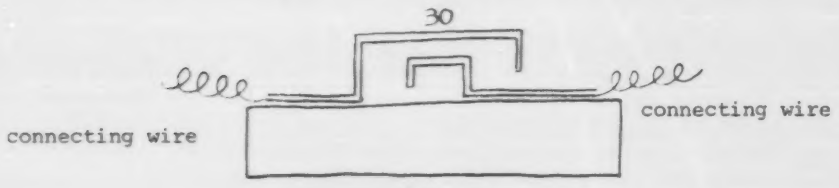
These will need to be purchased.

D. Bulb holders

Make a wooden base 6.0 cm x 4.0 cm x 1.5 cm.

Prepare two brass strips and drill the holes as shown.
Now screw the contacts to the base.
Connecting wires should be inserted under the contacts (Figure 6).





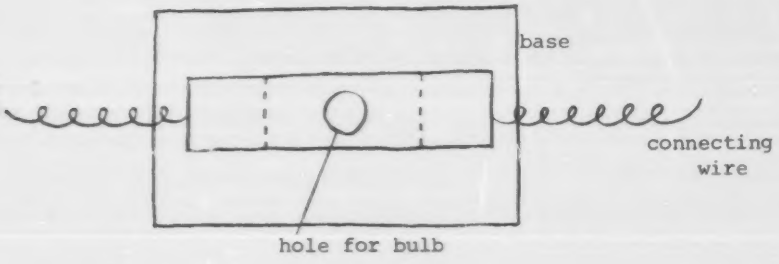


Figure 6

E. Connecting wires

Six wires are required in each kit. Thicker wire will last longer. The ends can be bent and twisted or soldered if stranded wire is used. A useful idea is to solder paper clips to the ends of the wire. Crocodile clips can also be used.

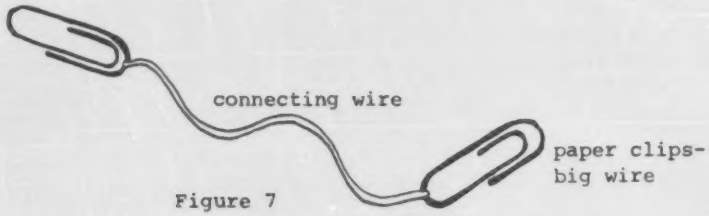


Figure 7

F. Crocodile clips

These are not essential and would need to be purchased. Other substitutes could be devised.

G. Switches - simple

Make a wooden base 6.0 cm x 4.0 cm x 1.5 cm.
Prepare two brass strips and bend as shown.
The holes can be drilled or made with nails.

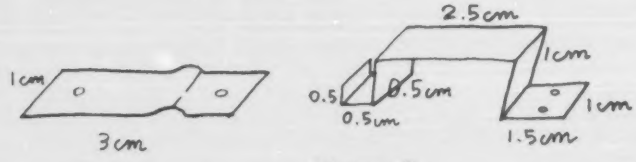


Figure 8

Mount the contacts on the base and attach connecting wires under the screws holding the metal strips.

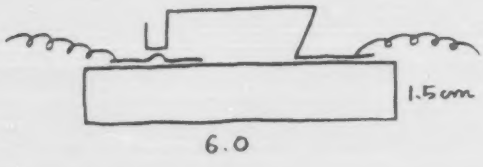


Figure 9

Switches - two way

Make a wooden base 6.0 cm x 4.0 cm x 1.5 cm.
Prepare three brass strips, drill holes as indicated and then bend to shape.

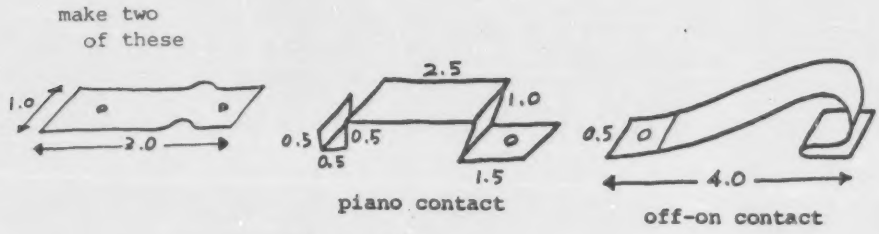


Figure 10

Mount the contacts on the base. The press contact should be screwed so it can rotate to make contact with either of the other contacts.

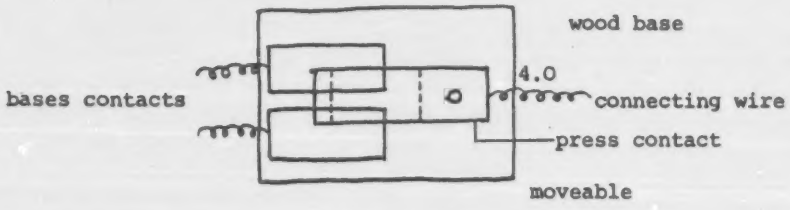


Figure 11

H. Resistor Holder/Conductivity Tester

Make a wooden base 6.0 cm x 4.0 cm x 1.5 cm.
Drill two holes which are very slightly smaller than the ends of the crocodile clips. Push the clips into the holes. They should be a tight fit. They could be glued in place.

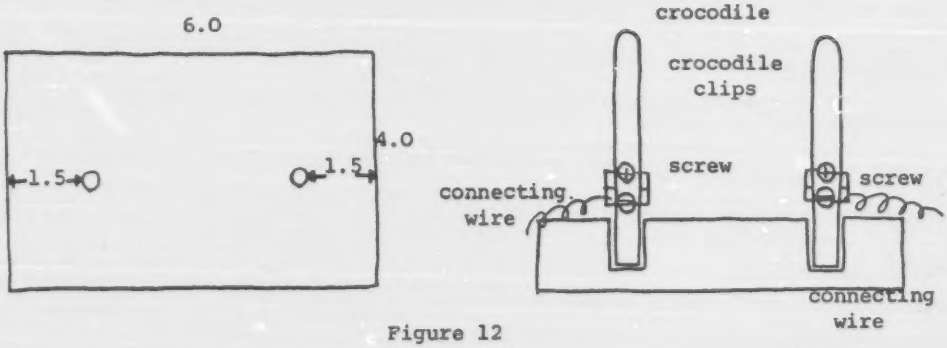


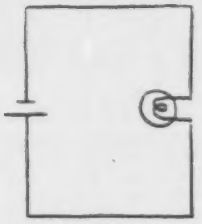
Figure 12

For testing conductivity place objects between the crocodile clips.
Various resistors can also be placed between the clips.

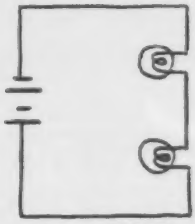
Use:

(a) Making circuits

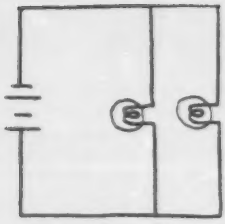
Have children make the following circuits:



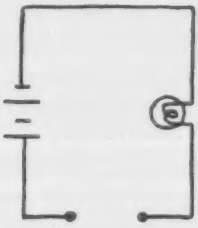
Simple Circuit



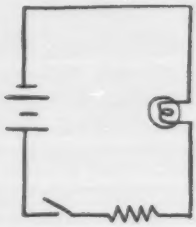
Steno Circuit



Parallel Circuit



Conductivity Tester
(Various materials placed across A - B to test for conductivity)



Effect of various resistors in a circuit.
(Place various resistors across A - B and observe effect on brightness of the bulb.)

Other circuits could also be devised.

(b) The heating effect of an electric current could be observed if a piece of nichrome wire is placed between the crocodile clips. The switch should only be closed for a short time or the battery will be flattened.

(c) Safety precautions to take when using electricity should be discussed.

(d) Conservation of electricity should be discussed. Ways children can prevent waste of electricity could be listed.

Modifications in Construction:

1. In place of wood for the bases acrylic or perspex could be used. It would need to be drilled and can be bent following warming in an oven. Rivets could be used to hold contacts in place.

2. Metals other than brass could be used but brass is best because it has the property of springing back.

ELECTRICITY KIT 2

Description:

A kitset of materials for use in teaching children about the magnetic effect of an electric current. Age group 9 - 12.

Objectives:

Content

Use of this kitset of materials should enable children to:

- explain that an electric current flowing in a wire or coil of wire has a magnetic effect.

Process Skills

Use of this kitset of materials should enable children to:

- construct an electromagnet;
- make a circuit which includes an electromagnet;
- measure the strength of an electromagnet;
- experiment to find the poles of an electromagnet.

Attitudes

Through using this kitset children should

- show curiosity about electromagnets and to look for their uses.

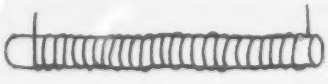
Materials:

Compass
Nail or screwdriver
Wire
Battery)
Bulb)
Switch) from Electricity Kit 1

Construction:

(a) Solenoid

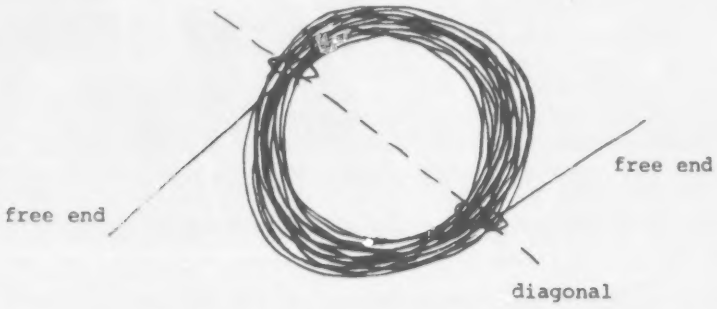
Wind 100 turns of insulated wire around a test-tube or a cardboard tube of approximately 1 cm diameter.



Leave 30 cm of wire at each end of the coil.

(b) Coil

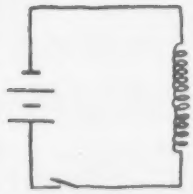
Wind a coil consisting of 20 turns. The windings can be made around a tube or three fingers. Leave 30 cm of wire at each end of the coil. After sliding the coil off the tube (or fingers) wrap two turns of the end wires around the coil to hold the loops in position. These should be diagonally opposite.



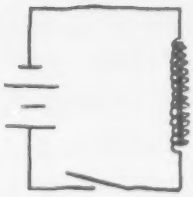
Use:

(a) Solenoid

(i) Place a compass approximately 5 cm from the end of the solenoid. Connect the solenoid in a circuit and turn on the switch briefly. Observe the movement of the compass needle. Reverse the current and observe the compass needle.



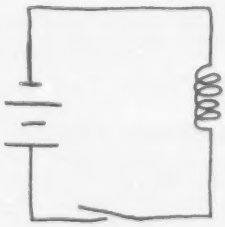
(ii) Repeat the previous experiment but with a large nail or screwdriver inside the solenoid.



(iii) Use the electromagnet from (ii) to pick up nails or tacks. Vary the voltage, number of turns in the solenoid and make predictions about the effect of changing these variables.

(b) Coil

(i) Place a compass in the coil and connect the coil in a circuit. Switch on the current and observe the effect on the compass needle. Reverse the battery connections and observe the effect on the compass needle.



Further Activities:

The children could

Make magnets

List the uses of electromagnets

Make an electromagnetic signal

Observe a 'relay' and discuss how it works.

APPARATUS TO INDICATE THE FLOW OF ELECTRIC CURRENT

Description:

The nature of electricity is difficult for pupils to understand. For older children this apparatus will assist them to explain the direction of movement of moving charges of current. Beside this pupils can use this apparatus as an indicator of current flow in any given simple circuit.

Objectives:

After using this equipment a student should be able to:

- explain that the direction of the current in a conductor is from the positive to the negative terminal;
- observe that the flow of a current in a given conductor can be shown with the use of a light emitting diode (LED);
- explain that when a light emitting diode is glowing it indicates that current is flowing through the circuit (ie, circuit is complete);
- develop interests and attitudes, such as curiosity, objectivity, honesty and open mindedness.

Materials:

Alligator clips

Dry cells (1.5 volt each)

Insulated wires (2 pieces, one black and one red, each about 20 cm long)

Light emitting diode (LED)

Nuts and bolts

Solder, and soldering iron

Wooden pieces,one (20 cm x 20 cm), and one 30 x 20 x 6 cm

Construction:

Drill a hole in the piece of wood so that the diameter of the hole is equal to the diameter of the LED. On one side of the wood make a groove of depth equal to at least the thickness of the wire (see Figure 1).

Solder one end of the black wire to the negative terminal of the LED. Similarly solder one end of the red wire to the positive terminal of the LED (see Figure 2).

Insert the LED in the hole in the piece of wood and fix the terminals of the LED and the connecting wires,in the groove with cellotape (Figure 3).

Attach alligator clips to the other ends of the black and red wire (Figure 4).

On the front side of the piece of wood draw an arrow head to indicate the direction of current (Figure 5).

Use:

1. Connect up the circuit using two dry cells as shown in Figure 6. If the diode is placed the wrong way round in the circuit it will not light. If the connection is correct the diode glows.

2. For advanced students use a transformer to give a 2 volt alternating source. The pupils will be surprised to see the diode lights regardless of the way it is connected. This can lead to a discussion that alternating current changes periodically.

Note: The LED must not be connected to a source of more than 2 volts. It needs a very small current to glow, so do not connect it in series with any electrical equipment.

Before soldering the connection, determine which terminal of the LED is positive and which is negative by using 2 dry cells.

For frequent use the LED should be connected in series with a resistor of 100-1000 ohms.

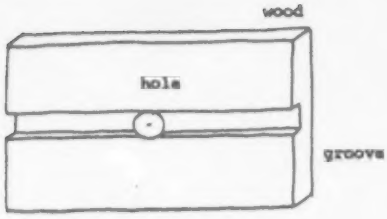


Figure 1

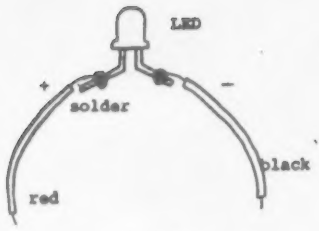


Figure 2

Figure 2

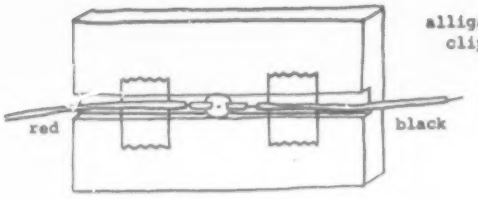


Figure 3

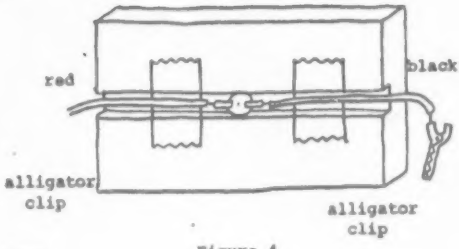


Figure 4

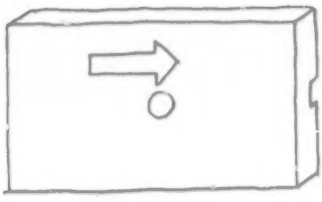


Figure 5

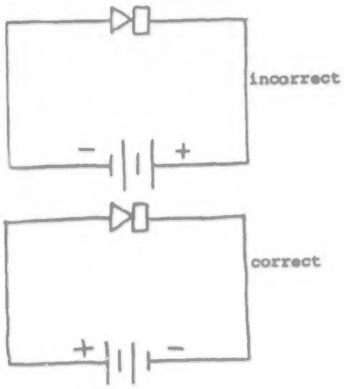


Figure 6

NEON BULB DETECTOR

Description:

This teaching device develops the concept that when some objects are rubbed they acquire electric charges. The mechanical energy spent through frictional force appears as the light energy of a glowing neon bulb in the absence of any other source of electrical energy.

(The same physical concept explains the phenomenon of lighting. The clouds get charged by the rubbing of water particles against air. The discharge of a charged cloud to the earth results in lightning.)

Age group: 10 - 12 years

Objectives:

Using this aid students can:

- produce static charges and discharge these through a neon bulb;
- deduce that static charges are produced only when non-conducting substances, such as plastic or polythene are rubbed by substances, such as metal held in an insulated handle, fur, or wool.

Materials:

Neon bulb with low striking voltage (eg, approximately 70 - 100 V).

Polythene sheet (approximately size 20 cm x 20 cm).

Metal sheet (aluminium, copper, tin or zinc approximately 10 cm x 10 cm)

A small piece of polythene wrapping paper.

Construction:

No construction involved.

Use:

Dry the polythene sheet and the metal plate with a dry cloth.

Place the polythene sheet on a wooden table.

Hold the metal plate using the piece of polythene wrapping. Take care that no part of the body or hand touches the metal sheet.

Rub the plate a few times against the polythene sheet (Figure 1).

Gently lift the metal plate about 3 - 4 centimetres above the polythene sheet (Figure 2).

Hold one of the leads from the neon lamp in one hand and while holding the metal plate in the insulating material in the other, touch the other lead of the bulb on the metal plate. Observe what happens (Figure 3).

Repeat the experiment using some other metallic plate and non-conducting material such as plastic or ebonite.

Modifications:

Note that experiments with static electricity are best performed on a dry day. When the air is humid charges quickly leak away from the objects. Metals are good conductors and the charge on the metals instantly leaks away when touched by any part of the body. Therefore the metallic plate should be held carefully using some non-conducting material.

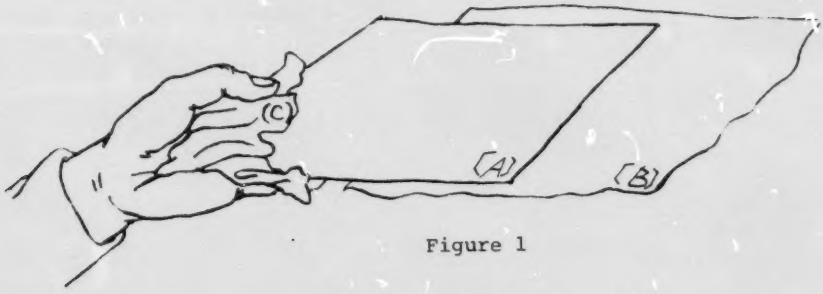


Figure 1

(A) Metal plate

(B) Polythene sheet

(C) Insulating material centre polythene wrapper

(D) Neon bulb

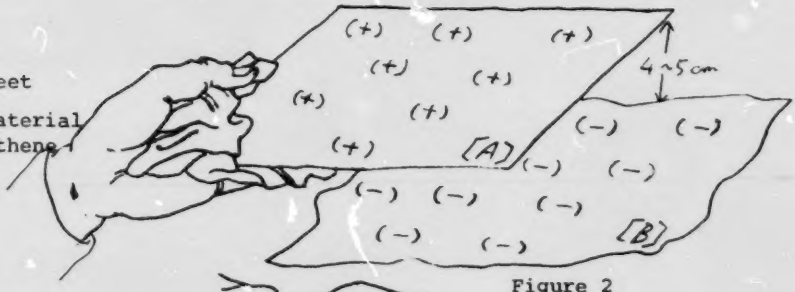


Figure 2

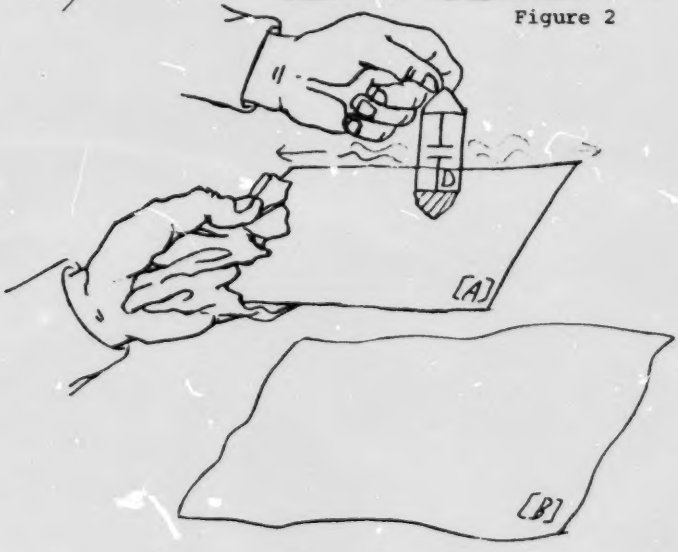


Figure 3

SIMPLE ELECTRIC MOTOR 1

Description:

This device enables students to learn how electric energy can be converted to movement or mechanical energy. If the device is made by students they will be able to practice a number of manipulative skills.

Objectives:

As a result of making and/or using this motor students should be able to:

- explain the basic principle of an electric motor;
- discuss how electricity may be changed to mechanical energy.

Materials:

Battery (6 volts)

Bar Magnet

Enamelled copper wire (approximately 2- 3 metres)

Paper clips

Test tube, tube or other cylindrical object

Construction:

Wind the wire around a test tube or similar object leaving 50 mm free at each end of the wire as shown in Figure 1.

Slip the coil off the test tube as shown in Figure 2.

Bind the coil together with the two ends of the wire, twisting the two ends around the coil two or three times, with one end coming from the front of the coil and the other from the back as shown in Figure 2.

Bend two paper clips as shown in Figure 3 and fix them to the cell. Scrape the enamel insulation from the ends of the coil. Paint enamel or liquid paper or nail polish on one side of the bared piece of wire.

Use:

1. Assemble the materials as shown in Figure 4.
2. Place the magnet near the coil.
3. Gently spin the coil and if the magnet is in the correct position the coil will continue to rotate.

Figure 1

Figure 2

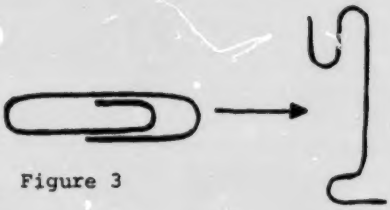


Figure 3

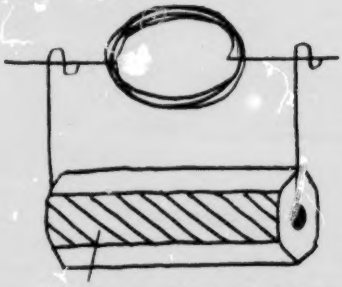


Figure 4

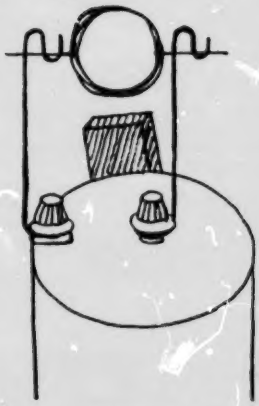


Figure 5

ELECTRIC MOTOR 2

Description:

This apparatus demonstrates the basic principles of:

- the electric motor;
- the electromagnet;
- attraction and repulsion between the poles of magnets;
- transformation of electrical energy to mechanical energy.

Objectives:

As a result of making and/or using this motor students should be able to:

- discuss attraction and repulsion between the poles of magnets;
- construct an electromagnet;
- explain the basic principles of an electric motor.

Materials:

Enamelled or cotton covered copper wire (approximately 0.4 mm diameter, 1 metre long)

Copper wire, approximately 1.0 - 1.5 mm diameter, 20 cm long

2 Iron nails, 5 cm long

5 Iron nails, 2 cm long

Islet button

Piece of copper or aluminium foil (3 cm x 3 cm)

Sewing needle

Tin strip, 5 mm x 5 cm, from an old tin can

Vinyl or plastic or rubber tubing, 4 to 6 mm diameter

Vinyl or plastic or rubber electric wire sleeving or insulation, 2 cm long

Block of wood, 3 cm x 2 cm x 2 cm

Battery, 3 V

Construction:

The vinyl (or plastic or rubber tubing) is cut to the required length and the two nails (5 cm) are inserted into it (as shown in Figures 1, 2 and 3). The sewing needle is pushed through the center of the tubing perpendicular to the nails as shown in Figure 4. The piece of electrical insulation sleeving (2 cm) is fixed to the sewing needle by passing the needle through the hole in the casing. (Figures 5 and 6)

The enamelled or cotton covered wire is wound close together (in one direction) on the vinyl/rubber tube from A to B (Figure 7).

The copper foil is cut into two rectangular pieces so that when they are spread over the cylindrical portion (Figure 8) the two are about 1 mm apart.

The two ends of the wires are placed over the two foil pieces so that there is electrical contact between the wire and the foil and tied onto the cylindrical vinyl (or rubber) casing (Figure 9) using string or thread. The block of wood is nailed on to a side of the wooden board as shown in Figure 11. The tin strip (with a hole made as shown in Figure 10) is nailed to the wooden block as shown in Figure 11. The bottom part of the islet button is attached to the wooden board so that its centre is vertically below the hole in the tin strip (Figure 11). The needle and the coil are fixed, as shown in Figure 12, with the point of the needle inside the islet's cup and the upper part of the needle passing through the hole in the tin strip. Two pieces of copper wire (10 cm long) are fixed close to one end of the wooden board (using nails) so that the two ends of the wires touch the two pieces of foil (Figure 12).

Place the opposite poles of two magnets close to the ends of the coil and connect the battery to the ends of the copper wire (Figure 12). The coil and magnets should be in the same plane.

Note: If the motor does not rotate check to see that (a) the two wires are touching the foil and (b) they are making a good electrical contact.

Use:

This electric motor, and its parts, can be used to demonstrate/observe the following:

1. The magnetic effect of an electro-magnet.
2. The polarity of an electro-magnet.
3. The reversal of an electro-magnets polarity when the direction of the electric current is reversed.
4. Repulsive and attractive forces between magnets (in this case an electro-magnet).

Figure 1

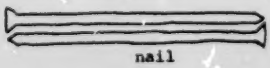


Figure 2

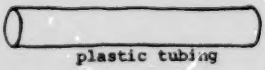


Figure 3

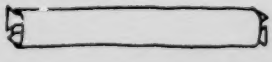


Figure 4

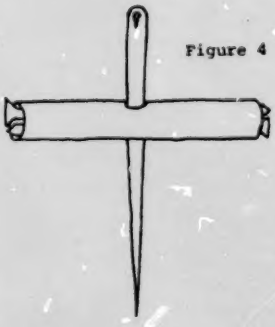


Figure 5

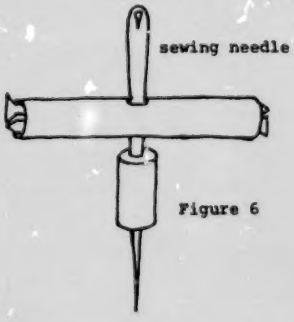


Figure 6

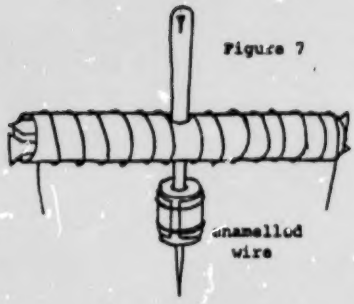


Figure 7

Figure 8

Figure 9

Figure 10

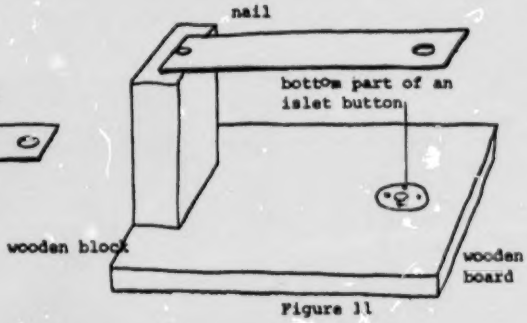


Figure 11

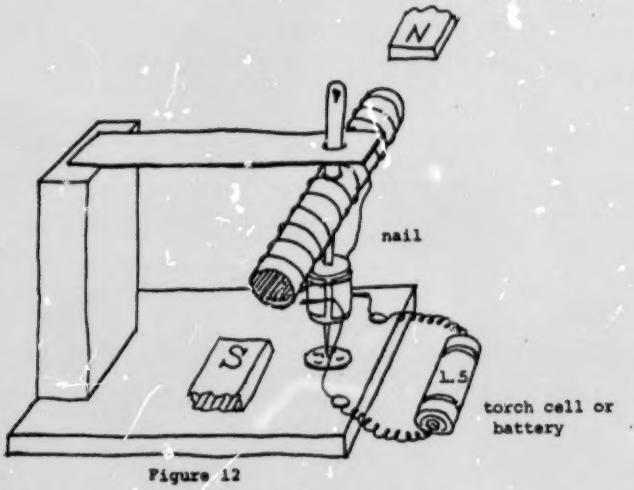


Figure 12

GALVANOMETER

Description:

This is a simple galvanometer for detecting small electric currents.

Objectives:

As a result of making and/or using this device students should be able to:

- demonstrate the magnetic effect of current and explain its application in electrical measurement;
- indicate the existence of current, the intensity of current and the direction of current.

Materials:

Used razor blade

Sewing needle

Drinking straw

Small cork

Aluminium sheet of medium gauge (3.5 cm x 14.5 cm)

Cardboard

Copper wire (enamelled) (1 mm diameter and 5 - 6 metres long)

A block of wood (1.5 cm x 6 cm cross section)

Cellotape

Construction:

Wind the copper wire around the block and use the cellotape to secure it in the shape shown in Figures 1 and 2.

From the aluminium sheet cut out the shape shown in Figure 3, then bend along the lines marked to make a stand for the coil (Figure 4).

Insert the needle through the central axis of the cork (Figure 5). Cut slots into the cork so that it will fit into the razor blade as shown in Figure 6.

Fix the drinking straw to the needle as shown in Figure 7.

Stroke the razor blade with a magnet so that the razor blade becomes magnetized.

Insert the needle into the holes in the aluminium stand and if necessary adjust the razor blade in the slot of the cork, so that the pointer (drinking straw) is vertical.

Make a box from cardboard so that the aluminium stand is inside and the coil of wire rests on the box.

Cut out a cardboard scale (shown in Figure 8) and, after drawing in the scale shown, paste this scale onto the side of the box.

Use:

When an electric current flows through the coil it will rotate, moving the pointer (straw) across the scale. In this way the device can be used to:

(a) detect electric current

(b) measure or compare different currents, and

(c) detect the direction of flow of electric current.

Figure 1

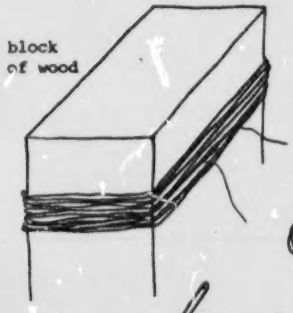


Figure 2

Figure 3

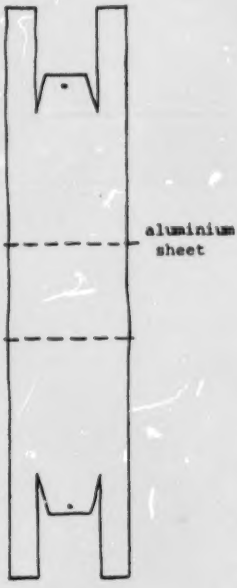


Figure 4

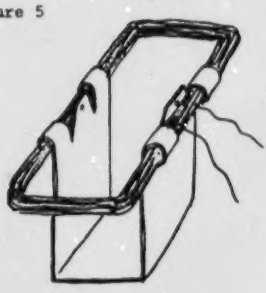


Figure 5

Figure 6

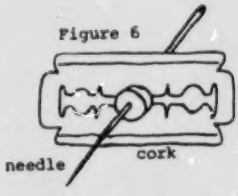


Figure 7

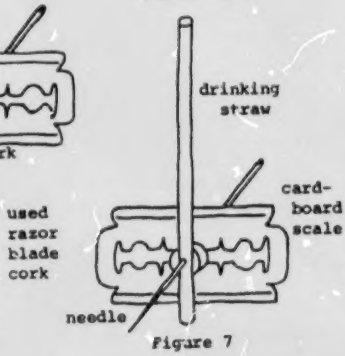
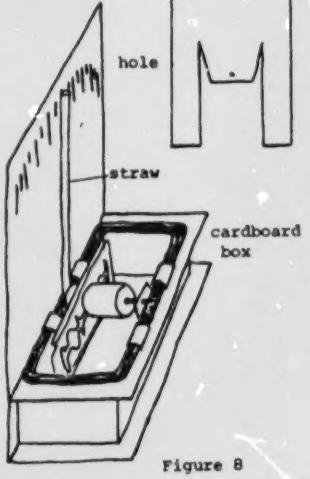
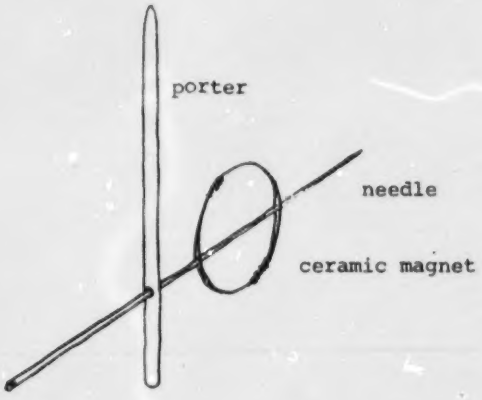


Figure 8



Modification:

In place of the magnetised razor blade use a small ceramic magnet mounted along the length of the needle (Figure 9).



BUZZER

Description:

Electromagnets are used in many electrical devices and tools. In this activity children construct and operate an electric buzzer. As a result they will find out about the relationship of electric current and magnetism as well as finding out how a buzzer operates.

Objectives:

Content

Through making this buzzer students should be able to:

- explain that there is a magnetic effect associated with an electric current;
- explain the working of a buzzer.

Skills

The students can:

- construct a simple electric buzzer;
- make a circuit for operation of the buzzer.

Construction:

Make an electromagnet as follows

Figure 1

Construct the buzzer as shown in Figure 2.

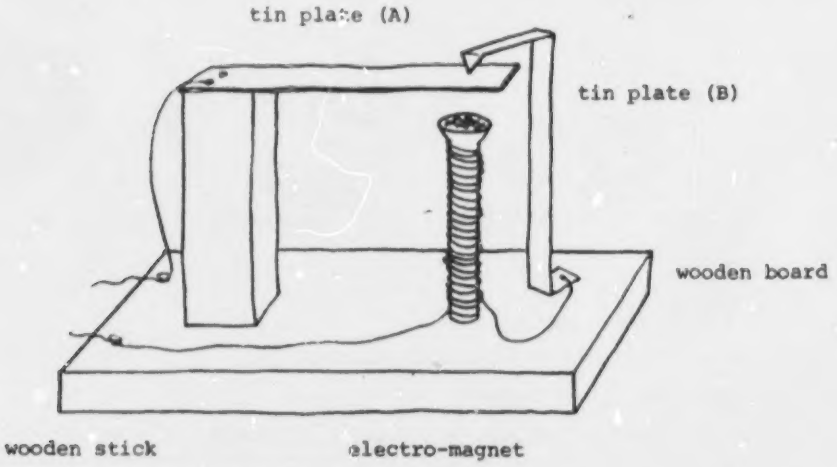
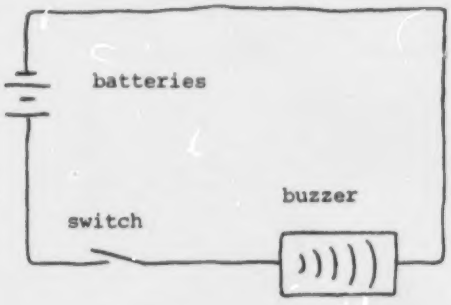


Figure 2

Adjust tin plate (B) so it touches tin plate (A) lightly.

Use:

Connect up the buzzer as shown in the following circuit.



Adjust the pieces of tin plate A and B until the buzzer makes a sound.

Discuss with the children how the buzzer operates.

Find other objects which use electromagnets.

BASIC LIGHT KIT

Description:

This kit is designed to enable teachers to perform a series of experiments on light. It consists of a number of parts which can be assembled and used to carry out most of the activities on light at the elementary level.

Objectives:

After completion of these activities students should be able to:

- explain the following basic concepts of light:
  - light enables us to see;
  - a ray of light travels in a straight line;
  - light can be reflected;
  - light can pass through some materials better than others;
  - light cannot pass through opaque objects;
  - a shadow is formed when light is blocked by an opaque object;
  - a shadow cast by an opaque object depends on the distance the object is from the screen or the source of light;
- use the following process skills:
  - observing
  - measuring
  - inferring;
- develop skills in handling and using equipment;
- develop the interests and attitudes of curiosity, honesty, objectivity and open-mindedness.

Materials:

Glass tumbler of water

Hammer

Nails

Plane mirrors of various sizes and thickness (see diagrams)

Protractor

Saw

Scale, eg, metre rod

Screws

Square sheets (10 cm x 10 cm) of the following

- aluminium/any other metal
- transparent plastic or glass
- wood (see diagrams)
- cardboard
- tracing paper or waxed paper
- cellophane paper

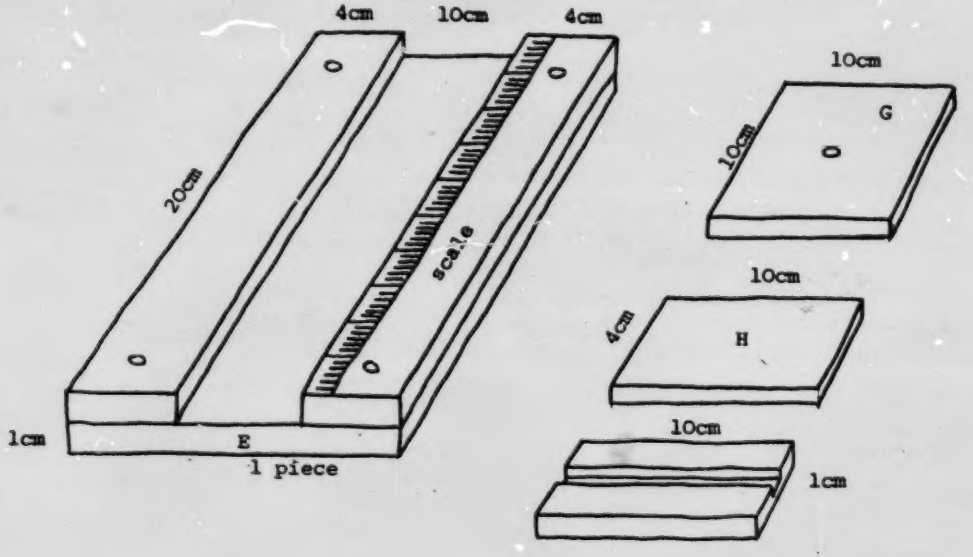
Torch with cells

Wood pieces - dimensions as shown in the diagrams.

Construction:

Using a saw cut the wood into small pieces of the required size as shown below.

Using these pieces of wood, and the other materials listed above, build the apparatus shown in Figure 1.



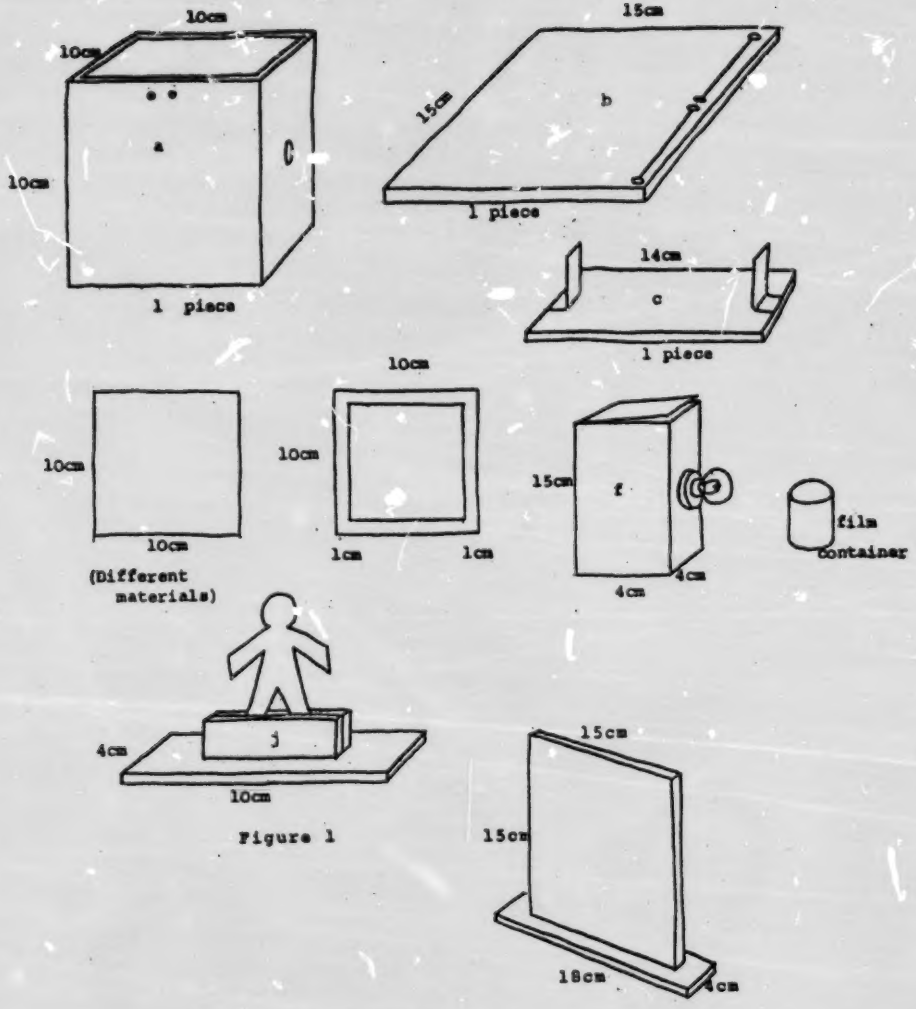

10cm
10cm
a
C
10cm
1 piece
15cm
15cm
b
1 piece
14cm
c
1 piece
10cm
10cm
10cm
10cm
10cm
1cm
1cm
(Different
materials)
15cm
f
4cm
4cm
film
container
4cm
j
10cm
15cm
15cm
18cm
4cm

Figure 1

Use:

Arrange the kit box as shown below:

Activity 1:

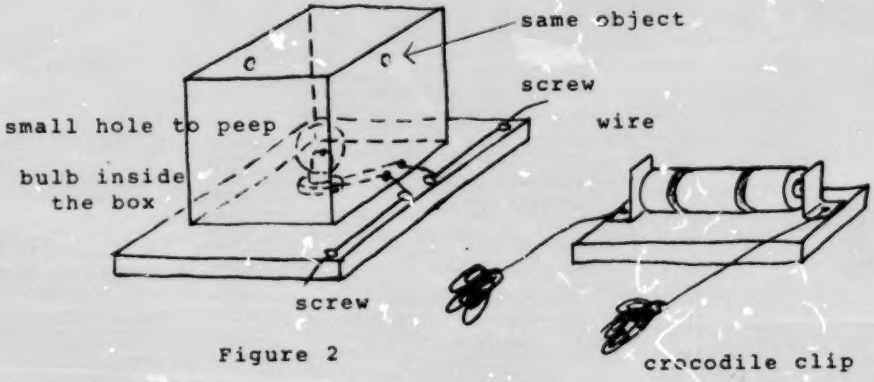


Figure 2

This arrangement can be used to show that light enables us to see things. By looking through the hole with the light switched off one cannot see anything inside the box. But when the light is switched on one can see an object inside the box. The following questions could be asked:

a Can you see the object when the light is switched off?

b What happens when the light is switched on?

c What makes the object visible?

Activity 2:

Students can observe light rays:

a Coming from the sun and passing through a small-hole in a door or window (the room beyond should be darkened);

b Passing through a small hole or slit in a piece of card held up to the sun;

c From a torch where the glass has been covered with opaque material in which a narrow slit has been cut.

Activity 3:

When sunlight passes through five slits (made in a card) and the light is allowed to fall on a plane mirror (as shown below), pupils can observe that rays of light move away from the plane mirror.

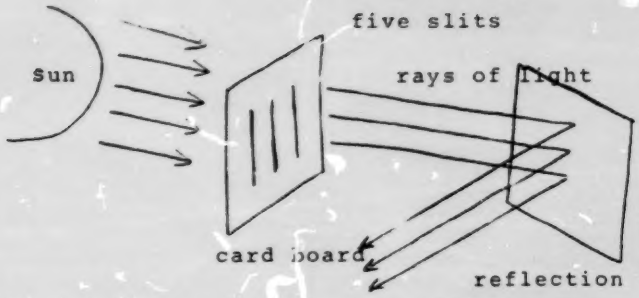


Figure 3

Instead of sunlight the light source prepared in this kit could also be used. Using this light source, and various types of polished or unpolished surfaces, pupils can observe and draw conclusions about reflection.

Activity 4:

Set up a plane mirror along with a protector and a light source (eg, torch with slit) as shown below and make the observations shown in the table).

No of observations	Angle at which the light is falling on the mirror	Angle at which light is moving away from the mirror
1		
2		
3		
4		
5		
6		
7		
8		

What conclusions can be drawn from these observations?

Activity 5:

Set up the apparatus shown below (Figure 5)

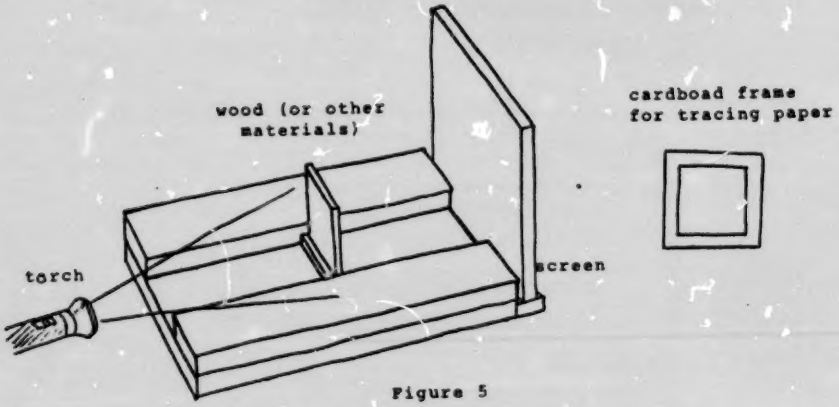


Figure 5

Place different materials in the holder such as transparent, semi-transparent, opaque sheets, etc, and record observations. These observations will indicate that light can pass through certain types of materials (transparent/clear) easily, and part of it can pass through other materials (semi-transparent). But light does not pass through some materials (opaque).

Activity 6:

Set up the apparatus shown below (Figure 6).

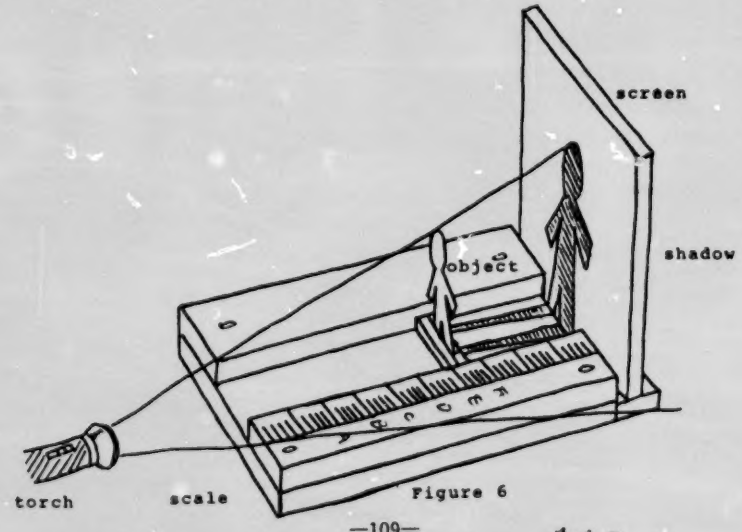


Figure 6

Can the shadow be seen? What happens to the image when the object is moved closer to the screen or source of light? Keep the object at positions A, B, C, D, E and F and measure the size of the shadow/image and record the data in tables like those shown below:

Position of the object	Size
A	
B	
C	
D	
E	
F	

The source of light (torch) has to be kept at the same place in front of the apparatus throughout the shadow experiment.

MODEL OF A CAMERA

Description:

This apparatus demonstrates that the image formed by a convex lens can be focussed on a screen. This image is real, inverted and diminished. The device also shows that the intensity of the image depends on the brightness of the object and on the amount of light going through the lens.

Objectives:

The students can:

- explain that the intensity of the image can be varied by varying the size of the aperture (opening) of the lens;
- show that the shape of the lens opening does not affect the shape of the image.

Materials:

Old chalk box or similar size cardboard box.

Convex lens, eg, inexpensive perspex lens.

Tracing paper.

Cardboard.

Construction:

Hold the lens in front of a piece of paper so as to get a clear image of a distant object.
Measure the approximate distance from the lens to the piece of paper (l).

Cut the box so that the length of the box is equal to (l). Figure 1.

The top of the lid of the box is cut out and tracing paper is pasted on its sides to form a flat screen. Figure 2.

A circular hole (diameter about 2 mm less than that of the lens) is cut out on the front face of the box. Figure 3.

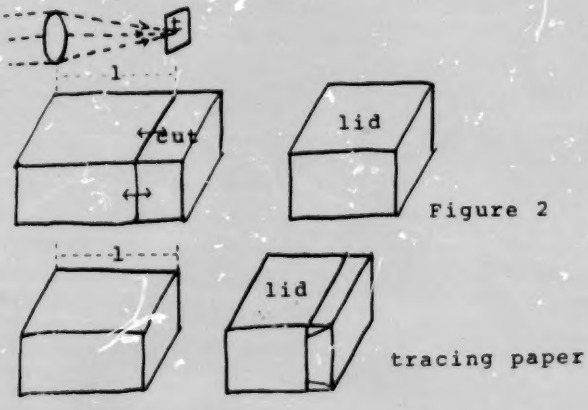


Figure 2

Figure 1

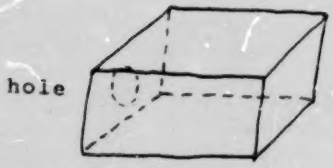


Figure 3

The lens is placed on the hole (from inside the box) and fixed in place using tape -- Figure 4, or using a piece of string or wire. (Figure 5)

Two pieces of cardboard P_1 and P_2 are fixed on to the face of the box (from outside)
(The glue is applied only to one half of the piece of cardboard P_1 and P_2)

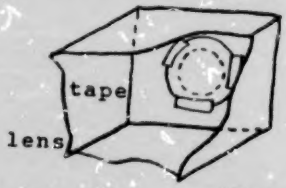


Figure 4

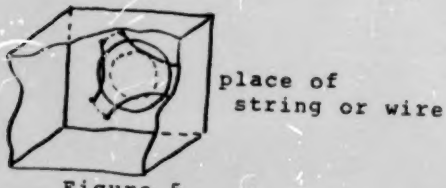


Figure 5

Circular holes (lens apertures) are cut out in a piece of cardboard (Figure 7). The diameters of the holes becoming smaller in size. The width of the cardboard (d) is made such that it can be inserted through the opening between P_1 and P_2. (Figure 8.)

This arrangement enables the size of the lens opening to be varied.

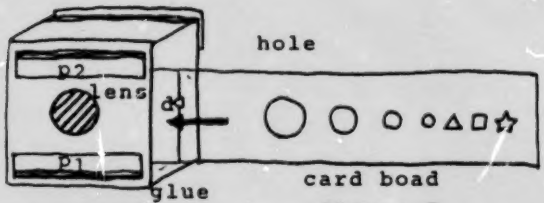


Figure 7

Figure 6

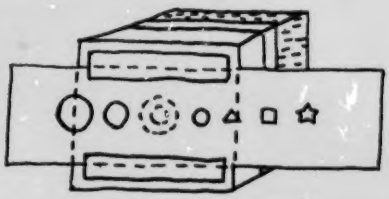


Figure 8

Use:

Using the longest lens aperture, point the camera to a distant object and adjust the screen -- (tracing paper) to get a clear, focussed image on the screen.

1. What is the size of the image compared to the object?

2. What is the nature of the image formed?

3. What happens to the image when one half of the lens is covered?

4. What happens to the image when the camera - (without any adjustment) is pointed at a closer object - (about 2 - 3 metres)?

5. What happens when the distance between the lens and the screen is varied?

6. Change the lens and aperture of the camera and observe the image on the screen.

7. What happens to the image when the shape of the opening is not circular?

A SIMPLE TELEPHONE SET

Description:

A simple telephone set made from cans, paper and thread.

Objectives:

The students can:

- explain that sound can be transmitted from one place to another through a solid, eg, thread;
- construct a simple string telephone;
- use the process skills of observation and interpretation of data.

Materials:

Juice cans (2)

Sheets of thin paper (2)

Thread (5 metres)

Cellophane tape

Match-sticks (2)

Construction:

Remove both ends of the cans.

Connect the match-sticks, paper and thread as shown in the diagrams.

Tape the sheets of paper over one end of each can as shown. (Figure 2). These should be stretched tight.

Use:

1. Use one can as the mouthpiece and the other as the receiver. (Figure 3)
2. Test if sound travels along the thread by having it pinched half way (Figure 4) or connected to a third can (Figure 5).

Modification:

Fix a small piece of match-stick to a short string and attach this to the thin piece of paper as shown (Figure 6). Observe the match-stick when a pupil is talking into the mouthpiece. Pupils can observe that:

(i) the match-stick vibrates
(ii) the louder the sound, the greater the vibration.

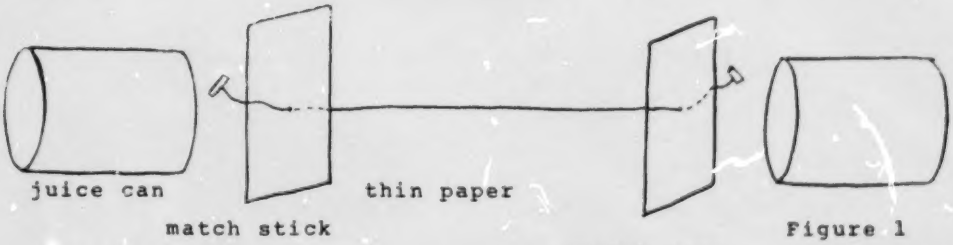


Figure 1

Figure 2

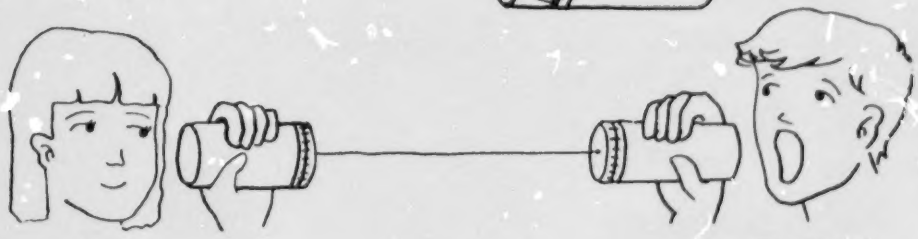


Figure 3

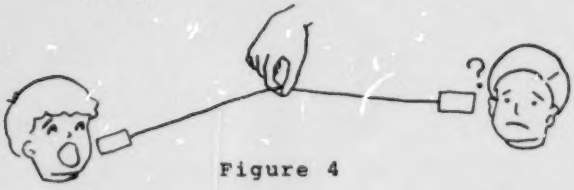


Figure 4

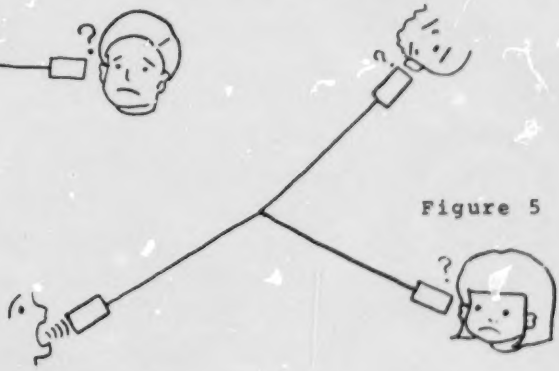


Figure 5

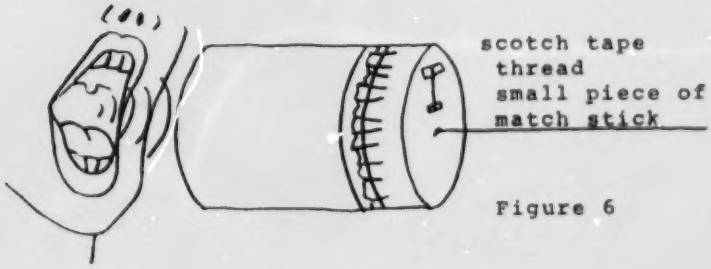


Figure 6

FRICTION

Description:

This apparatus is suitable for a single student, or groups of students performing experiments on friction. It shows the frictional effect of different kinds of surfaces.

Objectives:

The students can:

- explain that friction is everywhere and that it is a force that opposes motion;
- observe the retarding effects of various surfaces on the motion of objects, eg, smooth, rough (sandy/stony), muddy;
- demonstrate that the force exerted by the surface on a body against the direction of motion of the body varies with the nature of the surface.

Age group: 7 to 9 years

Materials:

Mud

Nails (2 cm long)

1 plywood sheet (80 cm x 40 cm x 1 cm)

4 pieces plywood (80 cm x 1 cm x 1 cm)

Saw and hammer

String (50 cm long wire 42 cm long)

Small toy-car

Sand and small stones

Construction:

Saw a piece of plywood, 80 cm long, 40 cm wide, and 1 cm thick, then four pieces of plywood, 80 cm x 1 cm x 1 cm.

Fix the four plywood pieces on the plywood surface using hammer and nails as shown in Figure 1.

Tightly fix a wire along the width of one side using nails. (See Figure 1.)

The first track is left smooth. The second is covered with a layer of sand and stone particles. The third track is covered with a layer of mud.

Tie a small toy car on the end of a piece of string.

Tie a hook with weights to the other end of the string.

Use:

1) Place the apparatus on top of a table. (See Figure 2)

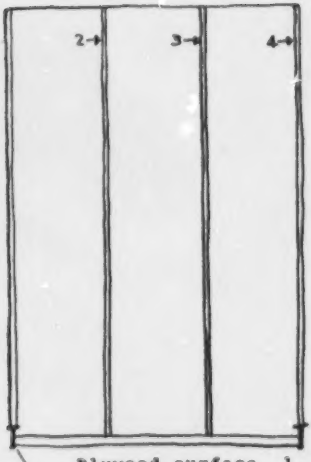
2) Put the toy car on one end of the smooth surface with the string over the wire. Let the weight hang and observe the car move.

3) Put the car on the sandy surface. Add enough weights to make the car move.

4) Repeat step 3 on the muddy surface.

5) Compare the weights needed to move the car.

Figure 1



1, 2, 3, 4 are playwood pieces
80cm x 1cm x $1cm^3$

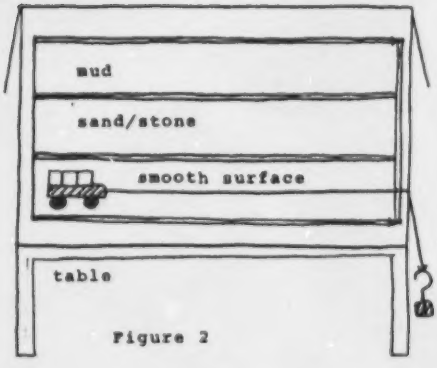


Figure 2

COTTON REEL TRACTOR

Description:

Children are fond of making and playing with moving toys. In this activity the pupils make and operate a simple cotton reel tractor and use it to develop the process skills of measuring, predicting and experimenting and the idea of variables.

Objectives:

On completion of this activity students should be able to:

- construct a cotton reel tractor;
- measure the distance travelled by a cotton reel tractor;
- make predictions about how far/how fast the tractor will travel with a given number of turns of the rubber band;
- experiment to find the effect on the speed and distance covered by the tractor as variables such as the number of turns of the rubber band or the size of pencil are altered.

Materials:

Candle

Cotton reel or film container

Drawing pin or tack

Matches

Pencil (short)

Rubber band (small but strong)

Construction:

Put a tack in one side of the cotton reel. Cut a piece of candle about 0.7 cm in width. Remove the wick. Thread a rubber band through the centre of the piece of candle and through the cotton reel. Place a pencil through one end and a short piece of match through the other (Figure 1).

If a film container is used holes will have to be drilled in the centre of the container and the cap. A method will have to be devised to hold the match stick so it does not rotate, eg, glue it in place.

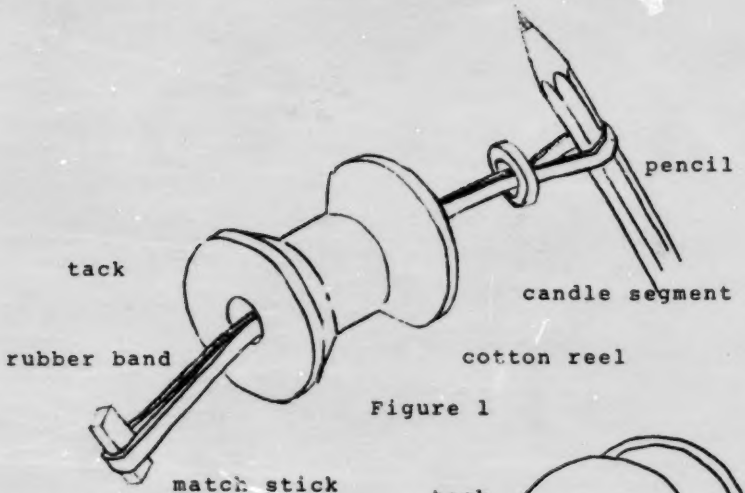
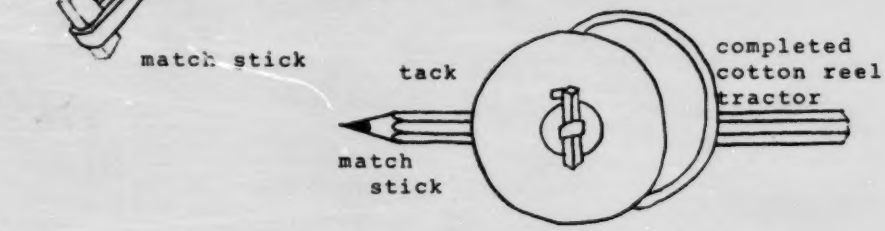


Figure 1



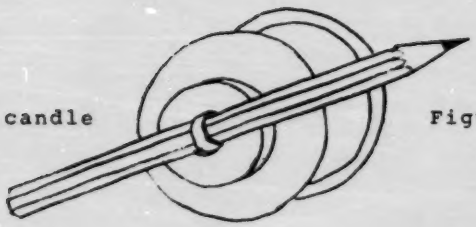


Figure 2

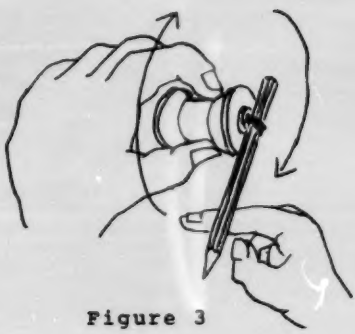


Figure 3

Use:

1. Hold the cotton reel with one hand and wind up the pencil with the other hand (Figure 3).

2. Place the cotton reel on the floor and observe its movement.

3. Complete the following table of data:

Number of Turns of Pencil	Time to travel 1 metre

4. Complete the following table of data:

Number of Turns of the Pencil	Distance Covered

5. Discuss the findings from 3 and 4. Try altering other variables to see their effect, eg,

   - size of pencil
   - thickness of rubber band
   - use of substances other than candle.

6. How could the tractor be improved to make it go further and faster?

WALKING GYROSCOPE

Description:

Probably every child has seen and played with a spinning top. It is often a source of wonder as to why a spinning top does not fall and yet the same top cannot stand by itself on its pointed end when it is not spinning. The stability of a moving bicycle, in contrast to a stationary bicycle, is another related example from every-day life. A wheel of a discarded bicycle can be used to develop the following concepts and process skills.

Age group 10 - 13 years.

Objectives:

Content

On completing this activity the students should be able to:

- explain that there is a relationship between the rotation of an object about its axis of symmetry and its stability.

(A heavy symmetical object spinning about its axis of symmetry acquires a property which is directed along the axis of rotation. The magnitude and direction of this property cannot be changed by forces acting at the centre of gravity or along the axis of rotation.)

Process skills

Observation

The students can observe the relationship between the stability of an object and its rotation about its axis.

Deduction

The students can deduce that a heavy symmetrical object spinning about its axis of symmetry is more stable (against external forces) that a non-spinning object.

Attitudes

Curiosity

The children develop curiosity about the stability of a moving bicycle or other rotating objects.

Materials:

A wheel from a discarded bicycle without tyre or tube but with a good axle.

A piece of iron strip to make a fork (approximately 0.2 cm x 5 cm x 1.0 m).

A small piece of wood (approximately 5 cm x 5 cm x 15 cm).

Two castor wheels.

Construction:

A bicycle wheel is mounted between the steel fork. The fork is supported on a wooden base. The wooden base is supported on two wheels. The distance between the vertical axis of the wheels should be about 3 or 4 cm. The procedure is illustrated in Figure (1).

Use:

(1) The whole apparatus should be placed on its wheels on a smooth floor or table. The wheel should then be spun by hand.

(2) Push the wheel quickly sideways, at the axle, to test its stability.

(3) It may be noted that under the action of forces described in (2) the wheel does not fall. Instead it moves on the floor with the plane of the wheel remaining almost vertical.

Modification:

See Figure 2.

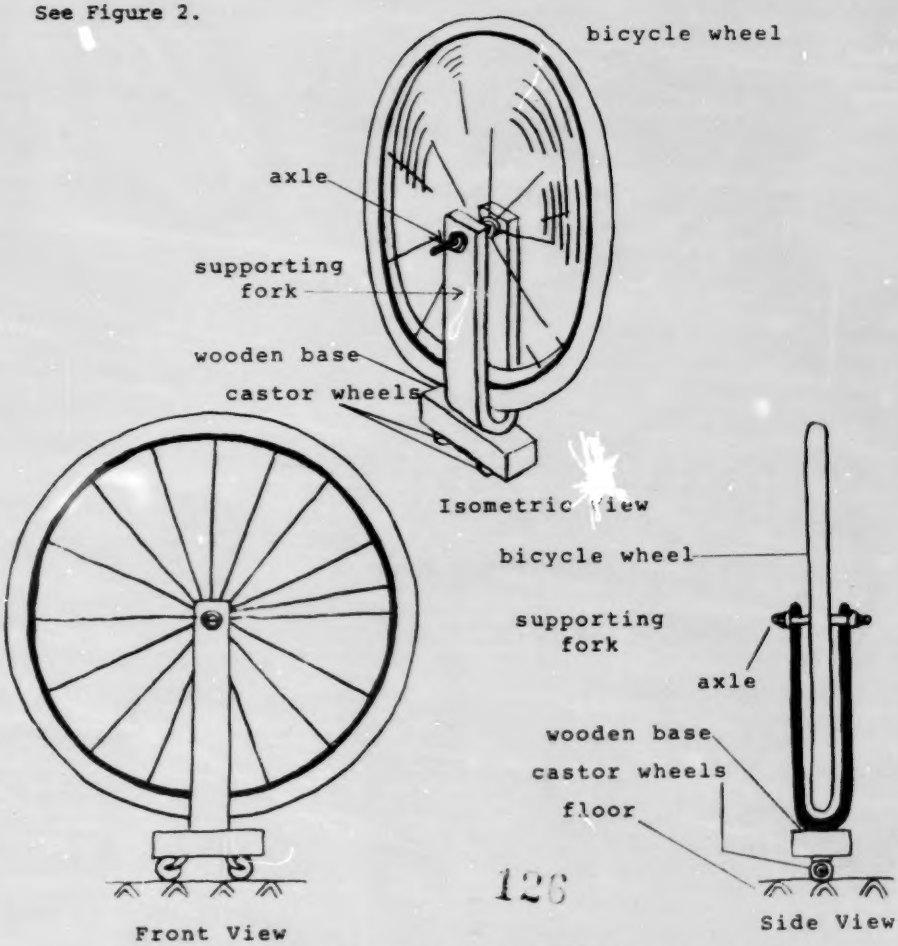


Figure 1 Walking Gyroscope

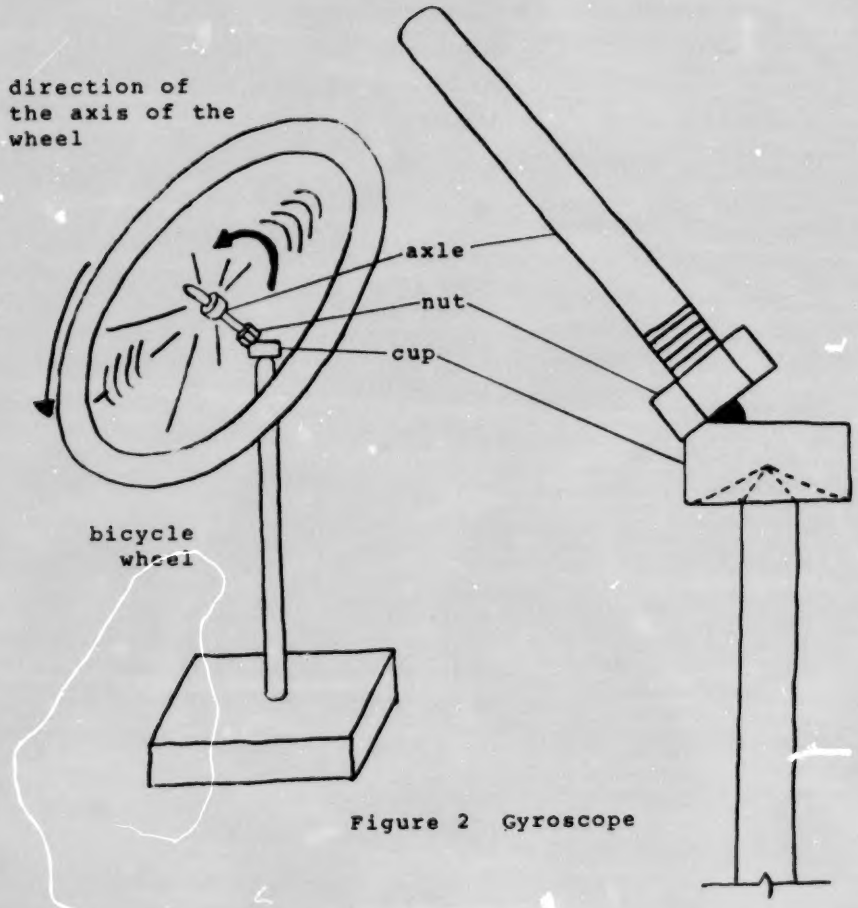


Figure 2 Gyroscope

AIR CIRCULATION

Description:

This is a device to show that heating and cooling air causes it to move.

Objectives:

The use of the device should enable students to:

- explain that warm air rises and cold air 'sinks';
- explain that warm air is lighter than cold air;
- observe examples of air movements;
- make inferences about the cause of air movements;
- discuss land and sea breezes.

Materials:

Transparent plastic sheet (20 cm x 15 cm x 0.2 cm)
Iron wire
Aluminium foil
Cardboard
Candle
Blocks of wood (2)
Small nails (4)
Cigarette, or other source of smoke
Ice
Cellophane tape

Construction:

Make four holes in the plastic sheet as shown in Figure 1 and form this into a cylindrical tube by taping the sides as in Figure 2.

Form a wire loop and fit this into the cylinder as shown in Figure 3.

Use the aluminium foil to make the wheel shown in Figure 4.

Assemble the equipment as in Figure 5.

Use:

1. Set-up the apparatus as in Figure 5 and observe the foil wheel. Observe also the movement of smoke in the cylinder tube.

2. Put a candle inside the tube as in Figure 6 and observe the wheel. Observe the movement of smoke in the cylinder tube.

3. Cool the upper part of the cylinder by hanging a piece of ice as in Figure 7. Observe the movement of smoke in the cylinder.

4. Set up the apparatus as in Figure 8 by putting a cube of ice in one end and a lighted candle near the other end. Observe the movement of smoke in the cylinder.

Modifications:

1. Use incense or a piece of cloth dipped in oil as a smoke source. The piece of cloth, when lit and then put out, produces smoke.

2. An electric bulb can be used to heat the air instead of a candle.

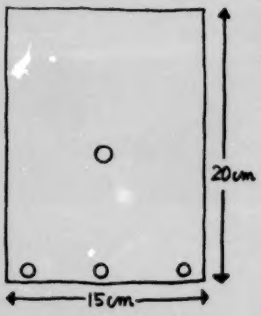


Figure 2

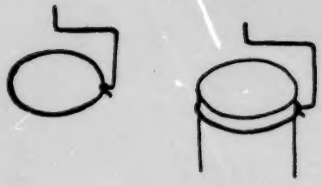


Figure 3

Figure 4

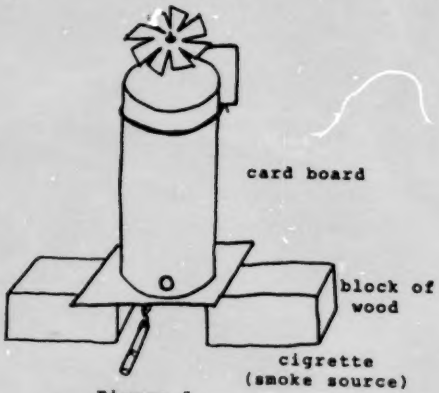


Figure 5

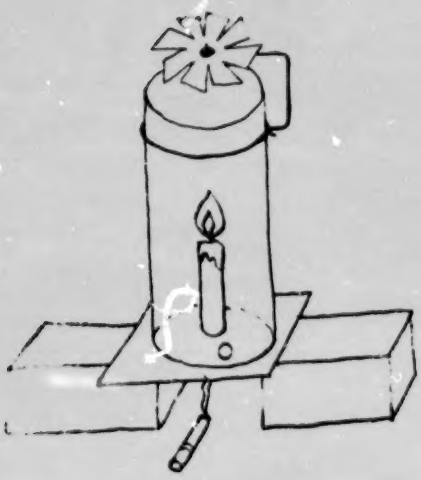


Figure 6

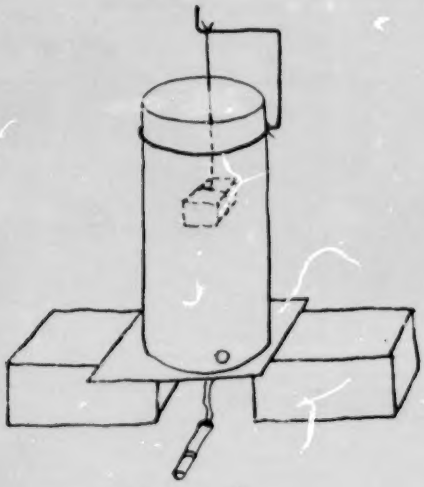


Figure 7

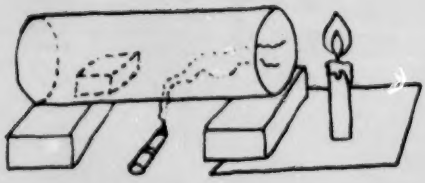


Figure 8

A WATER GENERATOR

Description:

This is a simple model designed to demonstrate how mechanical energy (obtained from falling water or wind) can be easily converted into electrical energy.

Objectives:

In building and using this model students can:

- see how mechanical energy from falling water can generate electrical energy;
- appreciate the conversion of mechanical energy into electrical energy.

Age level: 9 - 13 years.

Materials:

Aluminium sheet

Ball pen

Compass

D.C. motor (toy)

Flat pliers

File

Galvanometer (hand made-simple)

Hammer and drill

Nails

Rubber stopper (15 mm diameter approx)

Scissors

Screws and screw-driver

Wooden base

Construction:

Cut out a disc about 16 cm in diameter from the aluminium sheet. Divide the disc into 24 equal segments. Cut part way through these segments and twist each segment as shown in Figure 1. Punch a small hole through the exact centre of the disc with a nail.

Figure 1

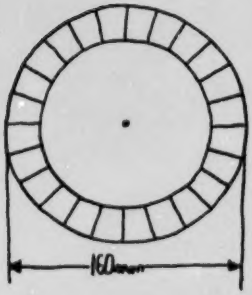


Figure 2

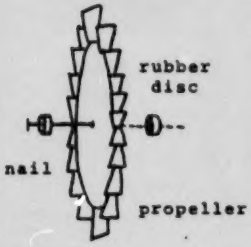
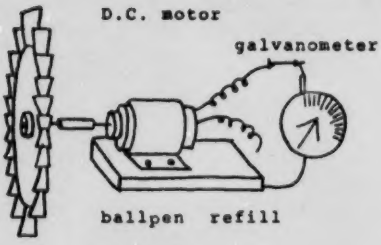


Figure 3



Cut out two small rubber discs from a rubber stopper (about 15 mm diameter and 5 mm thick).

Fit a nail through the centre of the first rubber disc, then through the hole in the aluminium disc, and finally into the second rubber disc as shown in Figure 2. The diameter of the nail should be just more than the shaft of the D.C. toy motor.

Join the above made propeller to the D.C. motor shaft with a piece of plastic tube (from an empty ballpen refill, about 15 mm long) as in Figure 3.

Fix the motor and propeller to the wooden base (Figure 3).

Use:

(1) Connect the terminals of the D.C. motor toy to a galvanometer with two flexible connecting wires.

(2) Let water from a tap or bottle strike the blades of the propeller. With a strong stream of water the propeller will rotate fast enough to generate sufficient current to move the galvanometer pointer.

Modifications:

In place of the galvanometer a light-emitting-diode (LED) could be used.

The device can also be used to show how the mechanical energy of moving air (wind) can also generate electricity.

CUP ANEMOMETER

Description:

An anemometer is a device to show how strong the wind blows. The stronger the wind blows, the faster the anemometer turns.

Objectives:

Content

The children can:

. explain that wind can make an object move;

. explain that the stronger the wind, the faster the object moves.

Process skills

The children can:

. observe the effects of wind;

. compare the strength of winds;

. interpret data.

Age group: 5 to 7 years

Materials:

Ice cream cups (4)

Pieces of light wood, 30 cm x 1 cm x 1 cm (2)

Small nails (4)

Long nail, thin enough to fit hole in ballpen casing

Ballpen casing

Wooden stake (20 cm x 2 cm)

For construction the following tools are needed:

Hammer

Drill

Chisel

Saw

Construction:

Make notches in the centre of the 2 pieces of wood and join as shown in the diagram (Figure 1).

Where the pieces of wood cross, drive a nail through the centre point (Figure 2).

Nail one cup to each end of the cross as shown in the diagram. (Figure 3).

Drill a hole through the centre of one end of the wooden stake. The ballpen casing should fit nicely into the wooden stake (Figure 4).

Insert the ballpen casing into the hole in the wooden stake.

Assemble the apparatus as shown in Figures 3 and 4.

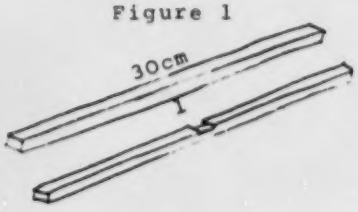
Make sure that the wood turns freely in the ballpen casing.

Mark or paint one of the cups so that its revolutions can be observed more easily

Use:

1. Go to an open space where there is wind and hold the anemometer above the head. See diagram (Figure 5).
2. Observe the turning of the anemometer.

Figure 1



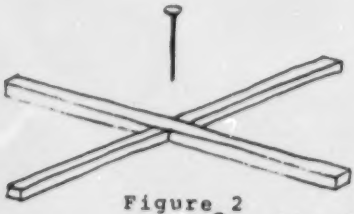


Figure 2

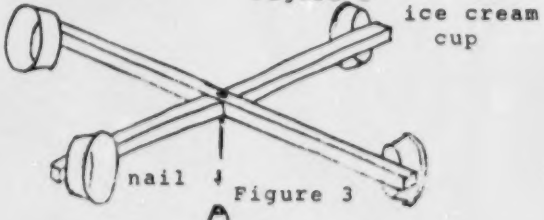


Figure 3

Figure 5

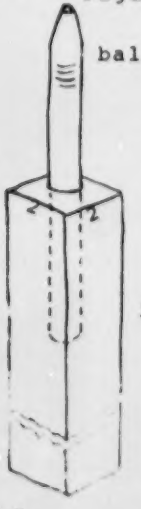


Figure 4

ANEMOMETER

Description:

An anemometer is a device to show how strong the wind blows. In this device, the stronger the wind, the higher the angle of swing of a piece of card.

Objectives:

The children can:

- explain that wind can make an object move (ie, exert a force);
- explain that the stronger the wind, the greater this force.

Process skills:

The children can:

- observe the effects of wind;
- compare the strength of winds;
- interpret data

Age group: 7 to 9 years

Materials:

Cardboard, 12 cm x 18 cm

Cardboard, 30 cm x 30 cm

Paper clips (2)

Knitting needle about 35 cm long such as the type shown

Tools needed for construction:

Marking pen

Punch

Ruler

Construction:

Make a scale on the bigger piece of cardboard as shown in the diagram (Figure 1). Punch a hole near the top of the cardboard along the central line.

Punch 2 holes near the top of the other piece of cardboard. The holes should be at equal distances from the centre.

Slip the cardboard scale through the knitting needle with the scale facing the pointed end.

Slip the paper clips through the knitting needle as shown (Figure 2).

Use:

Go to an open space where there is wind. Hold the knitting needle at arms length. Make sure that the knitting needle is horizontal.

Observe the swinging of the cardboard and note on the scale the strength of the wind. Do this 2 or 3 more times. Compare your observations.

Now try comparing the strength of the wind in different places.

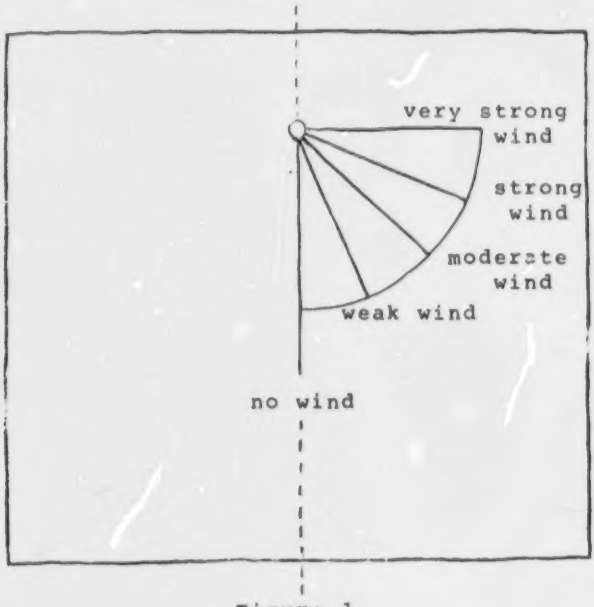


Figure 1

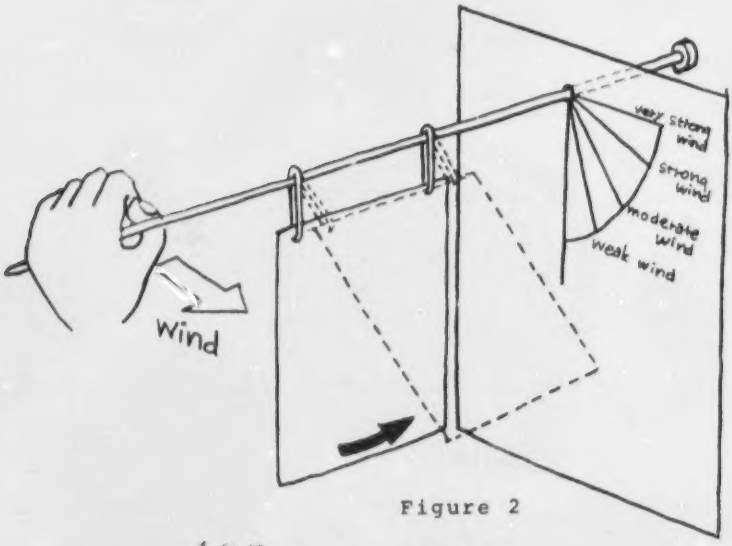


Figure 2

WIND VANE

Description:

A wind vane shows wind direction.

Objectives:

Content

The children can:

- explain that wind can make an object move;
- explain that the direction in which the object settles shows the direction from which the wind comes.

Process skills

The children can:

- observe the effect of the wind;
- compare the direction of winds from day to day;
- interpret data.

Age group: 5 to 7 years.

Materials:

Ballpen cover

Ballpen refill, used

Cardboard, 10 cm x 20 cm

Cellophane tape

Paper clips (if needed)

Paste or glue

Thin wooden stick or piece of bamboo about 100 cm long

Scissors

Construction:

Cut 2 cardboard arrows exactly like those in the diagram (Figure 1 and Figure 2).

Glue or paste the cardboard arrows and the ballpen cover as shown (Figure 3).

Tape the ballpen refill securely to one end of the stick or bamboo (Figure 3).

Place the ballpen cover with the glued arrow over the ballpen refill (Figure 3).

Attach a paper clip to the tip of the arrow to balance (Figure 3).

Make sure that the arrow turns freely (Figure 3).

Use:

1. Go to an open space where there is wind.
2. Hold the stick upright and observe the movement of the arrow.

Modifications:

The stick supporting the wind vane could also be stuck into the ground (Figure 4).

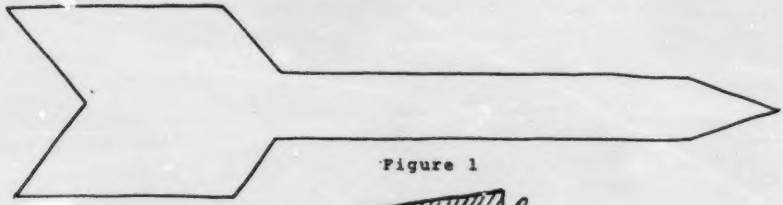


Figure 1

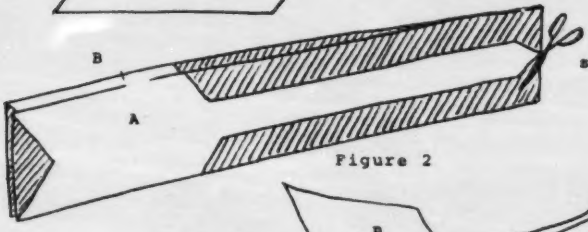


Figure 2

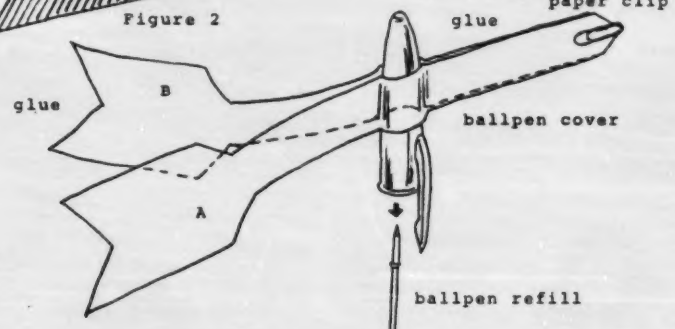


Figure 4

Figure 3

BAROMETER

Description:

A barometer is a device that shows changes in air pressure.

Objectives:

Content

The child can:

- explain that air exerts pressure;
- explain that air pressure changes at different times

Process skills

The children can:

- observe weather phenomena;
- compare air pressures;
- interpret data

Age group: 7 to 10 years

Materials:

Cellophane

Cellophane tape

Drinking straw

Felt marker pen

Glass jar, wide mouthed

Rubber band or string

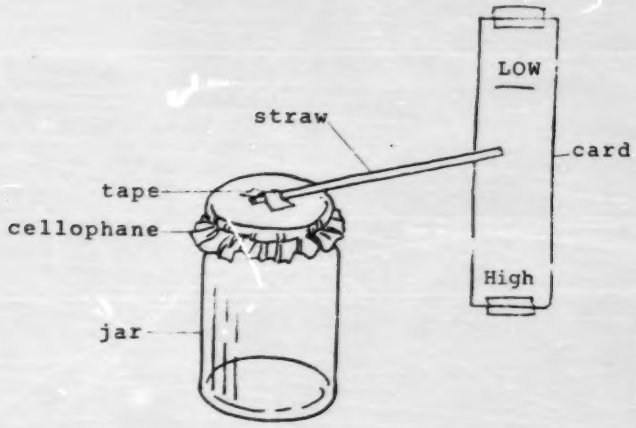
Thick paper strip

Construction:

1. Cut a piece of cellophane that is slightly larger than the mouth of the glass jar. Warm the glass jar and then stretch the cellophane over the mouth of the jar and secure it firmly with the rubber band and cellophane tape. This should be done on a cloudy day if possible.
2. Tape one end of the drinking straw to the centre of the cellophane.
3. Put marks on the paper strip as shown in the diagram.
   Tape it against a wall in such a way that the straw points to the middle of the paper strip.

Use:

1. Make a mark on the paper strip where the straw points.
2. Continue to observe the position of the straw on the scale for 3 to 4 more days. Make a mark on the paper strip for each observation.
3. The barometer could be calibrated against barometric pressures given by the local weather office.



HYGROMETER

Description:

A hygrometer is a device to measure the amount of moisture (humidity) in the air. This hygrometer makes use of a cellophane strip which is stretched by moisture.

Objectives:

The children can:

- explain that there is moisture in the air around us;
- explain that the amount of moisture varies from time to time.

Process skills

The children can:

- observe changes in temperature;
- measure temperatures;
- interpret data

Age group: 9 to 11 years

Materials:

Cellophane strip, 14 cm x 2 cm

Glue

Matchstick

Nail

Needle

Paper scale

Short wooden stick, 18 cm x 1 cm x 1 cm

Small wooden block, 1 cm x 2 cm x 2 cm

Thread

Wooden board, 30 cm x 20 cm

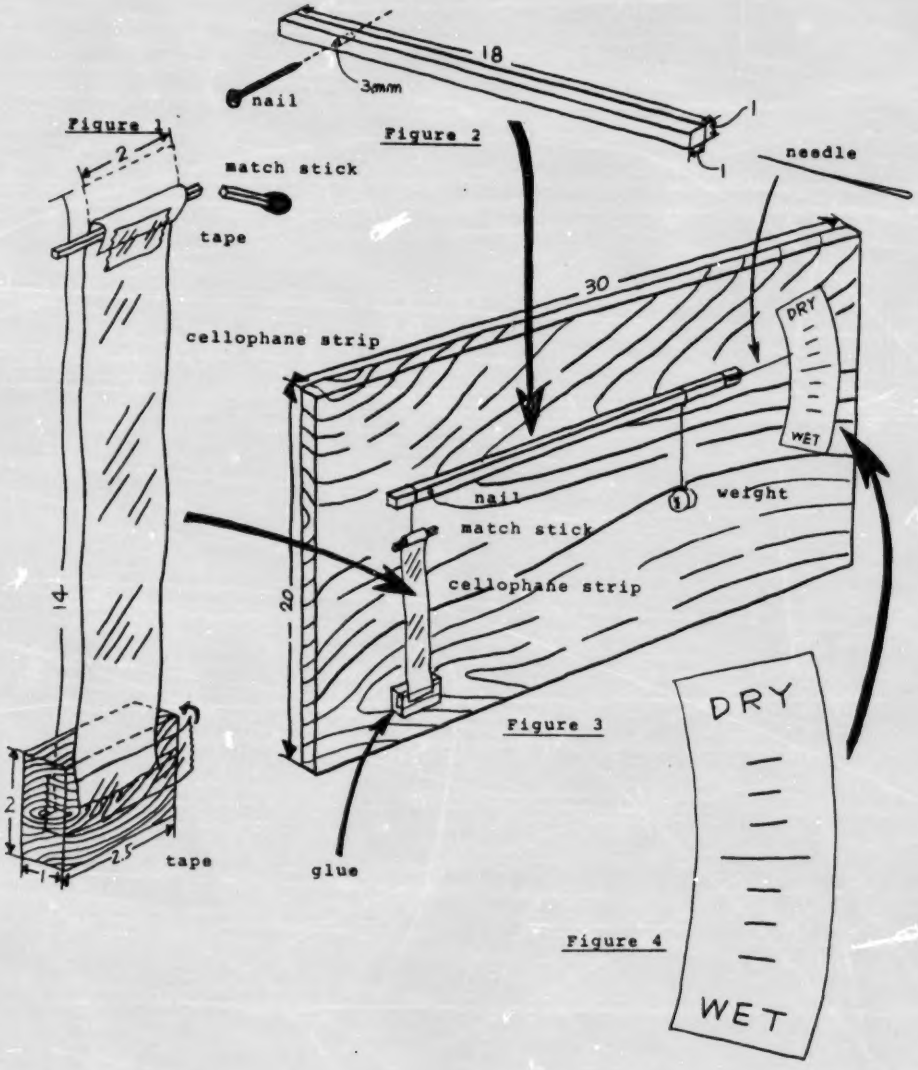
Weight, small

Construction:

1. Set up the apparatus as shown in the diagrams.
2. Adjust the weight so that the wooden stick is horizontal and the needle points to the centre of the scale.
3. Test the apparatus by blowing into the cellophane strip. Observe the position of the needle when the cellophane strip becomes moist.

Use:

1. Set up the apparatus in a part of the room where it would not be disturbed.
2. Observe the position of the needle at different times of the day.
3. Compare the observations.



STAR BOX

Description:

During the day it is impossible for students to see the constellations in the sky and this makes it difficult for them to appreciate how various stars make up the shape of a particular constellation.

In order to overcome this difficulty a star box can be made so that children can see the pattern of various star groups.

Objectives:

Process skills

The children can:

- observe the patterns made up by various stars and star groups in the sky;
- construct a star box

Attitudes

The children show interest and curiosity about stars.

Materials:

Bulbs, 100 w (2)

Bulb holders (2)

Cardboard sheets, black/blue in colour, 25 cm x 25 cm.

Hammer

Nails

Needle

Saw

Switch

Wire

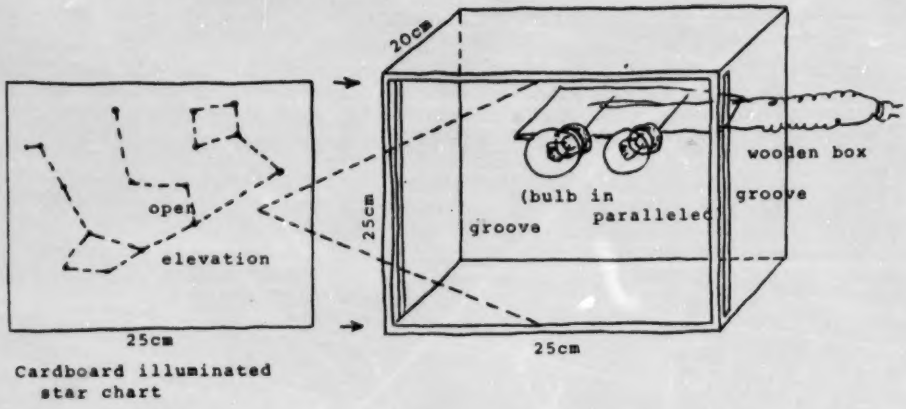
Wooden box, cubical, 25 cm x 25 cm x 20 cm with front side open.

Construction:

Construct a wooden box with an open front as shown. Cut slits in the two sides at the front so a piece of card can be inserted.

Fit with the 100 watt bulbs.

Cut several pieces of card of size slightly less than 25 cm x 25 cm to slide into the grooves. Draw a different constellation on each card and use a nail or drill to make holes wherever stars are located. If possible relate the size of the hole to the apparent size of the star when viewed from Earth. Use black card if possible. Draw in the shape of the constellation.



Cardboard illuminated star chart

Use:

Place a card in the Star Box, turn on the bulb, and allow the children to observe. Point out the various stars and give their names. Look at the shape made by the constellation. Discuss how it got its name. Repeat with the other cards.

Get the children to look for the various stars and constellations in the night sky.

Modifications:

The box can be used as a light source for viewing transparencies, slides, etc, if the card is replaced by a piece of translucent perspex, acrylic or plastic. In this case use only one bulb to avoid excessive build up of heat.

If no electric power is available use a 6v bulb in the box and connect this through a switch to a battery.

CHAPTER III

SYNTHESIS OF EXPERIENCES RELATING TO THE DEVELOPMENT OF APPROPRIATE AND LOW-COST AIDS FOR SCIENCE TEACHING

1. *INTRODUCTION*

Each workshop participant prepared and presented a country report dealing with the design, development and use of appropriate and low-cost aids for science teaching. On the basis of these reports, and additional information provided through discussion, the following synthesis has been prepared. Despite the diversity of experience within and across the participating countries, the synthesis reveals considerable commonality in several basic areas.

For convenience both for analysis/synthesis and procedure, the group conducting the task chose to report under each of the following headings. This has, in some instances, led to overlap but it has also provided a convenient scheme whereby readers of the report can focus on specific areas of interest. It has also provided a context within which the report can be interpreted:

1) Teacher education and development, including all aspects of pre- and in-service training;

2) Development and use of appropriate and low-cost aids;

3) Curriculum with attention to the place of science and the nature of the science curriculum;

4) Organization of education with respect to years of schooling and grades at the primary or elementary level;

5) Methodology or teaching strategies;

6) Co-ordination between relevant agencies;

7) Finance.

2. *TEACHER EDUCATION AND DEVELOPMENT*

Most of the countries of the region require their prospective science teachers to take one or more courses relating to skills in developing and using low-cost, indigenous instructional aids. Some like Australia, Bangaldesh, India, Japan, Korea, New Zealand, Pakistan, Philippines, Singapore, Sri Lanka and Thailand, have provided programmes for developing low-cost instructional materials in their pre-service training. Some extend these programmes up to secondary level (e.g., Bangladesh, China, India, Japan, Pakistan, Philippines, Singapore, Sri Lanka and Thailand).

In China and Malaysia, there is generally no regular requirement for such a course but science teachers usually take an option relating to the development of inexpensive teaching aids.

There are several countries in the region which have established special institutions for the development, testing and promotion of low-cost teaching aids for science teachers. Examples are the Bangladesh Educational Equipment Development Board-BEDB (Bangladesh). National Council for Educational Research and Training-NCERT (India), Students Science Education Center - SSEC

(Korea), Educational Media Services - EMS (Malaysia), National Educational Equipment Centre - NEEC (Pakistan), University of the Philippines Science Education Center - UPSEC (Philippines), Curriculum Development Institute of Singapore - CDIS (Singapore), Curriculum Development Centre - CDC (Sri Lanka), Institute for the Promotion of Teaching Science and Technology - IPST (Thailand). In both Australia and New Zealand, there is a growing programme of in-service education on a systematic, regular and repeated basis. Many of these programmes are concerned with the development and use of teaching resources and aids.

At the elementary level, in-service education programmes are a feature of almost all countries in the region. However, in most cases these programmes are intended to provide orientation and specific training in those concepts, skills or processes forming part of a specific curriculum.

The nature, style and duration of this training varies considerably from one country to another. Short but task-specific courses ranging from one day to three-day duration are very common in Australia, New Zealand, Singapore and Sri-Lanka, whereas courses of one to four weeks consisting of concept learning/ teaching new methodologies including the use of low-cost instructional aids are very common, for example, in Bangladesh, India, Japan, Korea, Malaysia, Nepal, Pakistan, Philippines, and Thailand.

In Australia and New Zealand, the provision of reinforcement through repeated or cyclic programmes is a feature. In these programmes, teachers receive training during a short intensive period and then some time later return to continue or reinforce the initial training. Other countries, like Sri Lanka, require training over a full year, during which time the teachers attend courses two or three times each month. Often those short-term courses are the result of teacher requests for training in specific areas of interest or need.

Teacher associations also play a significant role in determining the needs of their local teachers vis-a-vis development of low-cost aids (e.g., Australia, India, New Zealand and Singapore).

The analysis of the country reports revealed a number of apparent problems related to teacher education and development. Specifically, these included:

1) An acute shortage of professionally qualified specialists. For example in instructional technology, media graphic arts and laboratory techniques.

2) An acute need for establishing teacher education programmes based on special competencies, skills and attitudes for developing, designing, using, maintaining, and evaluating the effectiveness of low-cost teaching aids.

3) A need for professionally trained and skilled teachers in schools who can develop and use low-cost instructional materials in the classrooms.

4) In one-teacher primary schools where the teacher must teach all subjects in the curriculum in a crowded classroom situation, it has been almost impossible for the teacher to implement the real intentions of curricula based upon the development of science processes, skills and attitudes. Under these circumstances, it has been difficult for the teacher to spare time for the development of low-cost teaching aids.

5) Many teachers do not appreciate or understand the importance and effective role of low-cost aids in enhancing teaching-learning processes through first-hand concrete experiences.

6) Most of the teachers appear to possess inadequate knowledge regarding the production, repair and maintenance of equipment.

7) Many teachers have conservative attitudes toward curriculum reforms and demonstrate resistance to contemporary methods of science teaching including the use of improvised low-cost instructional aids.

8) Many teachers also show a lack of motivation or interest in accepting new teaching strategies which will improve classroom teaching through the active use of low-cost and hand-made teaching aids.

In spite of the above difficulties, there is evidence of a number of emerging trends supporting the use of low-cost/appropriate aids. These include:

1) A general trend away from the use of sophisticated equipment towards the use of low-cost and indigenous-based materials.

2) National governments are attaching increasing priority in their educational policies and plans to process-oriented, inquiry-directed, pupil-centred activities rather than content-oriented and teacher-dominated programmes.

3) New teacher education programmes are emerging which pay special attention to competencies, skills and attitudes for developing, designing, using, maintaining and evaluating the effectiveness of low-cost teaching aids.

3. *DEVELOPMENT AND USE/AVAILABILITY OF LOW-COST TEACHING AIDS*

Throughout the region, there is considerable variation in both the development of aids and their availability and use in schools.

This can be seen from the summary below:

Bangladesh: Several agencies are involved in the design, development and distribution of prototype teaching aids. These include the Bangladesh Educational Equipment Development Board, the Audio-visual Education Centre, the Toy Research Unit of the Children's Academy and Village Educational Resource Centres. In these agencies, there is considerable attention to the development of low-cost aids but this has not resulted in widespread availability of aids to schools.

China: A national inventory of science teaching aids has been developed and the policy is to provide this equipment to all schools. However, with almost one million elementary schools it has not been possible to supply many schools, particularly those outside the major cities.

India: The National Council for Educational Research and Training has developed and produced a basic kit for science teaching. Although some 25,000 units have been produced and distributed, this has only provided equipment for a small number of schools. Local manufacture of the prototype has, in most cases, not occurred. Some aids have been produced by commercial companies and purchased by individual schools when funds are available.

Korea: Several agencies are involved in the design, development and distribution of aids for schools and many schools have appropriate aids. However, class size and teacher inexperience limit the use of this material. A feature in Korea is the use of well-equipped out-door science activity centres.

Malaysia: Bodies such as the Educational Media Services and the Curriculum Development Centre have developed aids, some of which have been produced commercially. When made available to schools these materials are widely used.

Nepal: Despite the existence of a national science equipment centre, few equipment aids are available to schools and their use is therefore very limited in elementary schools.

Pakistan: Several agencies are involved as in Bangladesh. For example the National Educational Equipment Centre, the Educational Extension Centres, the Bureau of Audio-visual Aids, and the National Centre for Science Education. A teaching kit which includes low-cost aids has been widely dstributed.

Philippines: The Science Education Centre of the University of the Philippines has been active in developing and arranging for the production and distribution of aids to schools including an elementary science kit and a teachers' guide.

Singapore: Since June 1980, the national Curriculum Development Institute of Singapore (CDIS) has been designing and arranging for the production of science teaching aids. These will be available from January 1982 and are expected to be widely used as the new programmes are implemented.

Sri Lanka: Since 1972, government agencies with international support have developed and distributed science kits to secondary schools. Almost 50% of the elementary schools have been supplied with equipment. When equipment is in a school, it is widely and effectively used.

Thailand: The Institute for the Promotion of Teaching Science and Technology (IPST) has developed some aids as part of its curriculum materials development programmes. To date, most of these materials have been for secondary schools and only pilot elementary schools are currently receiving aids.

Australia, Japan, New Zealand: In these countries, there are no national research and development centres responsible for aids production. Aids are produced by commercial companies and purchased, when funds are available, by individual schools. Most schools are well equipped and the materials are in use.

Throughout the Asian region, there is a clear trend towards the design, development and supply of low-cost and appropriate teaching aids and for the encouragement of teachers to develop their own materials from locally available, indigenous materials. For many countries, these attempts are hindered by many of the problems previously mentioned, e.g., lack of personnel, inexperienced and inadequately trained teachers, and limited finance. At the elementary level, there are additional problems of class size, heavy teaching demands, and the fact that when equipment is available this is usually given to secondary schools.

4. *CURRICULUM*

Throughout the region, science is accepted as an important and essential part of the school curriculum. At the highest levels, i.e., grades 11 - 12/13, the science curriculum usually takes the form of one or more of the traditional science subjects, i.e., physics, chemistry or biology. Courses in these subjects usually stress content or knowledge in preference to the teaching or learning of broad science principles, processes or skills.

At the elementary (grades 1 - 5/6) level, the science programmes are more varied. In most countries, including Bangladesh, China, India, Japan, Korea, Malaysia, New Zealand, Pakistan, Philippines, Singapore, and parts of Australia, parts of the traditional sciences are integrated to form a single curriculum subject, science or general science. Apart from Australia, India and New Zealand, this single subject has a common content for all primary schools within a particular country, and in most it is a compulsory part of the curriculum, taking up some 10 - 15% of the total teaching time. In a few countries, science at this level is not compulsory and instead is taught as part of a broad curriculum area such as the 'Life Experience', seen in the Thai elementary school curriculum.

At the middle grades, i.e., grades 7 - 10, the nature of the science curriculum varies considerably. Most countries include science as a compulsory part of the curriculum and this normally takes the form of traditional subjects, integrated or general science, or life or living skills. However, within the majority of these countries, there is a common curriculum determined either at the national or state levels, and this, in the main gives priority to content or knowledge.

Among the particular problems associated with the place and nature of science within the school curriculum are the following:

1) The relative inexperience and limited science training of many teachers, particularly at the elementary level, has hindered the implementation of many recent curriculum programmes. Added to this, many teachers appear to lack confidence in teaching science at the elementary level.

2) Many new curricula focus on pupil activity which requires learning aids, such as equipment, and activity areas. The limited availability of each of these has restricted many new curricula and continues to make teaching of science a difficulty.

3) Many countries now place an emphasis on process-oriented programmes whereas teachers are used to, and most comfortable with, traditional content-based curriculum. Teacher resistance to change is an apparent,widespread problem.

A number of countries (Bangladesh, Japan, Malaysia, Nepal, New Zealand, Pakistan, Philippines, Singapore, Sri Lanka, Thailand,several states of India and several Australian states) have recently reviewed their primary curriculum. A trend in some countries is a move towards elementary school curricula in which science is not a specific subject. As a result, science as a specific subject will no longer be a part of the primary school curriculum of Bangladesh, Malaysia, or Thailand. In these countries, science has, or is becoming, an incidental part of the general curriculum, as for example in Thailand where

science is now being taught as part of the 'Life Experience' theme and in Bangladesh as part of 'Introduction to the Environment'.

In the majority of the countries within the region there is an increasing trend towards teaching science as an integrated subject at the lower and middle school levels and in using inquiry or problem-solivng approaches. School curricula are giving increasing attention to the development in the learners of process skills and attitudes. As a result, the development and use of low-cost, indigenous teaching aids is on the increase.

5. *ORGANIZATION OF EDUCATION AT THE SCHOOL LEVEL*

The organization of education (i.e., number of years of schooling and number of grades at elementary level) is shown in the table below:

Country	Years of schooling including pre university level	Primary or elementary level
Australia	12 years	6 (I-VI)
Bangladesh	12 years	5 (I-V)
China	10 years	5 (I-V)
India	12 years	4 (I-IV)
Japan	12 years	6 (I-VI)
Korea	12 years	6 (I-VI)
Malaysia	13 years	6 (I-VI)
Nepal	10 years	5 (I-V)
New Zealand	13 years	8 (I-VIII)
Pakistan	12 years	5 (I-V)
Philippines	10 years	6 (I-VI)
Singapore	12 years	6 (I-VI)
Sri Lanka	12 years	5 (I-V)
Thailand	12 years	6 (I-VI)

Note: Figures like '5 (I-V)' indicate '5 years of schooling at this level' and 'grades 1-5' at this level.

For most countries throughout the region, the large number of pupils, particularly at the elementary level, creates major problems in the organisation of classes, distribution and supply of aids, and supervision of activity-based lessons. As indicated earlier, most teachers at the elementary level are required to teach all subjects often in more than one grade.

6. *TEACHING METHODS OR STRATEGIES*

In a few countries (Bangladesh, China, India, Nepal, Pakistan, Sri Lanka), the main teaching method in use is teacher exposition/demonstration. There are a variety of reasons for this, e.g., large classes, lack of teacher background in science, lack of materials/aids, lack of teacher motivation. However there is a movement in most of these countries towards pupil involvement in activity-based programmes particularly at the secondary level.

In the remaining countries, teaching methods emphasize: a) activity-based programmes; b) inquiry, and c) a scientific approach to problem-solving. Pupil participation in the learning process is encouraged and the value of learning by doing is well recognized and accepted.

In some countries (e.g., Australia, New Zealand, Sri Lanka) there are out-door or field study centres and education out-of-doors is undertaken, particularly in biology and earth science studies. In these studies, direct observation and 'hands on' experience is emphasized.

Individualized science programmes are rare. Some teachers in Australia and New Zealand are using this approach. Problems such as the need for a lot of equipment, limited storage facilities and class management are some of the reasons for little progress in this teaching strategy.

In a number of countries, science fairs, competitions, and exhibitions are held on a regular basis. Pupils with, or without, teacher help plan and carry out research or projects, make scientific models, or prepare projects on a particular theme. These are displayed and viewed by the public and prizes are usually awarded. Sometimes there is sponsorship by the business community. These fairs are doing much to create interest in, and an awareness about the part science plays in the lives of all people.

Despite the emphasis on activity-based programmes, many countries have been unable to implement this teaching strategy. Many of the problems discussed earlier under 'Curriculum' have contributed including teacher attitudes, inexperience, lack of confidence, and class size. Added to these difficulties are the fact that:

1) Printed materials do not reflect the newer approaches and there is a lack of finance to produce new materials.

2) The difficulty and cost of implementing in-service programmes in the new strategies of teaching.

Despite the above difficulties, the policies supporting activity-based learning are slowly having effect as indicated by the following trends reported by the participants:

1) Increased use of activity-based programmes where inquiry methods predominate and pupils are actively involved in handling equipment.

2) Increasing recognition of the importance of developing the process skills of science.

3) The development of scientific attitudes and a scientific way of thinking is being encouraged.

4) To make activities more meaningful, activities related to the everyday experiences and environment of the pupils are being provided.

5) The importance of outdoor experiences is being recognized.

6) There is increasing emphasis on extra-curricular activities such as science exhibitions, fairs, clubs, etc.

7) The importance of in-service training of science teachers on the new methods of science teaching is being recognized and workshops and in-service programmes are being organized.

7. *CO-ORDINATION BETWEEN RELEVANT AGENCIES*

As reported under section 3 above, there are many agencies, such as curriculum development centres, science education centres and equipment boards, contributing to the design, development and use of low-cost teaching aids. In some countries, there appears to be close co-operation between these bodies, in others this is not quite so apparent. Regional workshops conducted by groups such as SEAMEO, ACEID, UNESCO, etc, are assisting inter-country co-operation. However, apart from the production and distribution of publications such as this inventory, there is little evidence, apart from the work of RECSAM, of any attempt to co-ordinate the work of individual countries with the establishment of regional centres designing and developing equipment for use in a number of countries.

8. *FINANCIAL SUPPORT*

Many countries report that financial constraint is the major factor limiting the design, development and use of low-cost teaching aids. Where there are large and increasing populations, this is a particularly serious problem. Frequently excellent low-cost aids are developed to the prototype stage but either cannot be mass produced or if produced, cannot be afforded by schools. Added to this, limited finance also prevents much of the re-training of teachers that is becoming increasingly necessary as new curricula and teaching strategies are being promoted. The support of international agencies, e.g., UNESCO, UNICEF, Asia Development Bank, etc. and bi-lateral aid programmes have assisted considerably. However, finance will undoubtedly continue to be a major difficulty in the years ahead. All countries recognize the importance of education and give it a high priority when preparing budgets. However, few at present can afford to make large increases in the percentage of gross national product (GNP) devoted to education.

CHAPTER IV

RECOMMENDATIONS

The exchange of ideas, experiences, discussions and deliberations among the participants of this Workshop led to the formulation of the synthesis of experiences and development of guidelines for developing low-cost and appropriate aids for science learning teaching as well as specific recommendations for promoting low-cost aids in the Asian and Pacific Region. The participants therefore recommend that individual governments, UNESCO and NIER carefully consider the recommendations contained in this chapter and implement them wherever possible. Accordingly recommendations are made to the individual governments, UNESCO-ACEID, and NIER.

1. *RECOMMENDATIONS FOR CONSIDERATION BY THE ASIAN AND PACIFIC COUNTRIES*

1) Governments attach high priority in their educational policies, plans and programmes to process-oriented, inquiry-directed and pupil-centred activities in elementary schools.

2) Governments endeavour to provide at least 4% of their G.N.P. for education purposes as recommended by UNESCO, several years ago, to the developing countries of Asia.

3) Governments provide special incentives for the training of specialists in the field of instructional technology, media development, graphic arts and laboratory techniques within and outside the country in order to meet the shortages of these specialists.

4) Teacher education programmes at the elementary level be reviewed so as to develop teacher competencies in science process skills, scientific attitudes and skills in developing low-cost teaching aids necessary for effective science teaching.

5) Governments give special attention to increasing the level of in-service programmes of teachers for development of requisite teacher competencies, processes and skills in developing and evaluating low-cost and appropriate teaching aids through formal and distance learning techniques.

6) To promote the development and use of low-cost and appropriate aids for science teaching at the elementary level of education, Governments take steps to ensure effective intersector and intra-sectoral coordination.

7) Items contained in this inventory should be tested by individual countries before their implementation to ensure their suitability to local conditions.

2. *RECOMMENDATIONS TO UNESCO-ACEID*

The following recommendations are proposed for the consideration of the UNESCO Regional Office for Education in Asia and the Pacific and ACEID for promoting and strengthening of national capabilities of the Member Countries for the development and implementation of programmes concerned with low-cost and appropriate aids in science teaching at an elementary level of education.

1) To strengthen efforts of the Member Countries in the development of low-cost and appropriate aids in science teaching by providing consultancy services and necessary financial assistance to the Member Countries.

2) To exchange and share experiences, ideas and strategies for the development of low-cost equipment/teaching kits among Member Countries of similar socio-economic conditions by arranging study visits, workshops and attachment programmes.

3) To act as a clearing house for dissemination of low-cost teaching aids, equipment, teaching kits and other innovative curriculum materials among the Member Countries.

4) To sponsor and organize a series of workshops to develop instructional modules for developing science process skills, scientific attitudes and related teacher competencies.

5) To organise additional mobile teams of specialists in the field of instructional technology to stimulate and promote low-cost teaching aids in Member Countries.

3. *RECOMMENDATIONS TO NIER*

The following recommendations are proposed for consideration by NIER in the organisation of their future programmes.

1) Educational tours be organised in such a way that ample opportunities be provided for discussion and interaction on topics and areas of special concern to the participants.

2) In order to complement this inventory and make it more effective for classroom use, NIER/ACEID take steps to produce "A Handbook of Teaching Activities" related to items included in the inventory.

3) NIER act as a clearing house for dissemination, to the participating countries, of appropriate and low-cost teaching aids, kits and other innovative curriculum materials developed and being implemented in the elementary schools of Japan.

4) NIER organise workshops on the development of appropriate aids for science teaching at the next level of education.

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